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A CONTRIBUTION TO THE PHYSICAL ANTHROPOLOGY AND POPULATION GENETICS OF SWEDEN

Variations of the AB0, Rh, MN and P Blood Groups

By

LARS BECKMAN

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A CONTRIBUTION TO THE PHYSICAL ANTHROPOLOGY AND POPULATION GENETICS OF SWEDEN

Variations of the AB0, Rh, MN and P Blood Groups

By LARS BECKMAN

The State Institute for Human Genetics,
Uppsala, Sweden

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TO MY WIFE

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I. INTRODUCTION

THIS investigation has been concerned with the collection of data on blood groups of the inhabitants of Sweden, and their study from the point of view of statistical population genetics. Its purpose has been to inquire whether there are local variations of gene frequencies within four different blood group systems viz. AB0, Rh, MN and P among the inhabitants of Sweden. In the light of what is already known about the serological genetic features of other European populations, it should then be possible to compare the degree and type of genetic similarity existing among different parts of the Swedish population with that of other populations.

As the central region of the so-called Nordic race, the Scandinavian peninsula must be considered an area of great anthropo-geographical interest. The Lapps are a particular case — a peculiar ethnic fragment whose origin is still obscure. East-Baltic elements of uncertain number and distribution are also found.

Problems attendant on such a history of migration may be illuminated by referring to the interesting investigations of some recent British scientists. Their work shows how effective an ethnological study of blood groups may be, even in such an industrialized and urbanized country as England, in demonstrating the survival of ancient differences in blood group frequencies.

Another important task is the comparison of already available anthropometrical data with serological characteristics.

In Sweden, little attention has been given to geographical variations in blood group frequencies. In Finland, on the other hand, extensive investigations of the AB0-system have been made. Norway has also seen the development of lively activity in this field during the past few years. The rest of Western Europe, and particularly the British Isles, have been thoroughly covered by blood group investigations.

The progress in England has been facilitated by her "blood-units" — institutions specializing in serology, where basic research is carried out in addition to the clinical routine. Intensive blood-donor activity during

World War II led to the collection of much data which have since been statistically analyzed.

During the past five to ten years, the blood group data available in Sweden have increased sufficiently to permit a statistical study and mapping. Military conscripts have, for a number of years, been typed. In early records, however, serum controls were not performed regularly; and their value is consequently somewhat diminished.

Very accurate data concerning the AB0-, Rh-, MN-, and P-systems have been collected at the Blood Group Serological Department at the State Laboratory for Forensic Chemistry in Stockholm. Since 1952, the Swedish Red Cross has sponsored vast campaigns to obtain blood donors throughout the country, and as a result valuable AB0- and Rh-data are now available in quantity.

Various individuals have put at my disposal the numerous serological determinations which are the basis of this report. This I should like to stress and also the fact that my own part has consisted largely of assembling the material and subjecting it to a population-genetical analysis. My primary interest has been the determination of the major features of variations in Sweden; thus very small population differences such as those between parishes or villages have not been included in this survey.

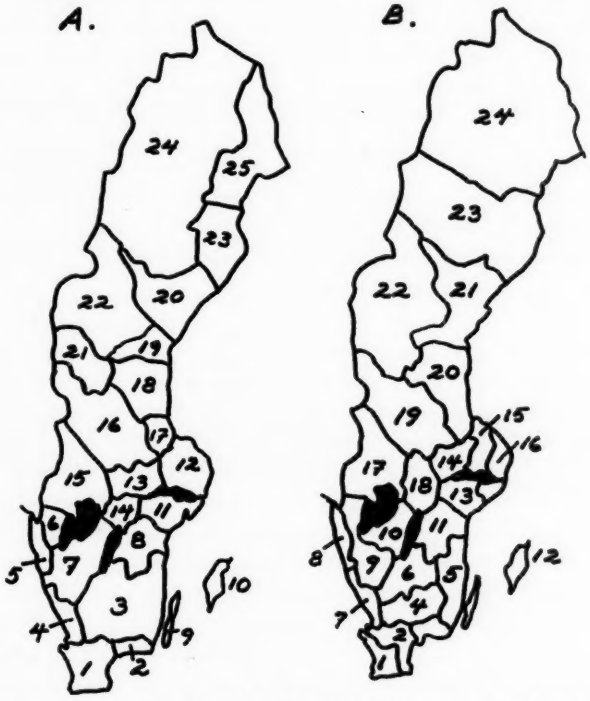
II. THE PROBLEMS

The following problems have been considered.

I. Do significant geographical variations in the frequencies of different blood-groups exist in Sweden?

II. From a knowledge of the serological-genetical characters of the Lappish, East-Baltic, and West-European populations, can we find where in Sweden these three elements are most strongly represented?

III. Do the results of the blood group investigations support the an-



Map 1. Sweden. Historical division into "landskap" (A) and administrative division into "län" (B).

A: Landskap

1. Skåne
2. Blekinge
3. Småland
4. Halland
5. Bohuslän
6. Dalsland
7. Västergötland
8. Östergötland
9. Öland
10. Gotland
11. Södermanland
12. Uppland
13. Västmanland
14. Närke
15. Värmland
16. Dalarna
17. Gästrikland
18. Hälsingland
19. Medelpad
20. Ångermanland
21. Härjedalen
22. Jämtland
23. Västerbotten
24. Lappland
25. Norrbotten

B: Län

1. Malmöhus
2. Kristianstad
3. Blekinge
4. Kronoberg
5. Kalmar
6. Jönköping
7. Halland
8: Göteborg och Bohus
9. Älvsborg
10. Skaraborg
11. Östergötland
12. Gotland
13. Södermanland
14. Västmanland
15. Uppsala
16. Stockholm
17. Värmland
18. Örebro
19. Kopparberg
20. Gävleborg
21. Västernorrland
22. Jämtland
23. Västerbotten
24. Norrbotten

thropogeographical and migration theories based on anthropometrical data?

As the discussions which follow deal to a large extent with geographical distributions, I include here two maps of Sweden showing historical and administrative divisions (Map 1).

The following administrative units are distinguished in Sweden:

Län	corresponds	to	the	English	county
Härad	„	„	„	„	jurisdictional district
Tingslag	„	„	„	„	assize division
Socken	„	„	„	„	parish.

The historical division into landskap (provinces), sometimes coinciding with the division into län (counties), is older than the latter, which was established in 1634.

III. EARLIER INVESTIGATIONS

A. ANTHROPOMETRICAL INVESTIGATIONS

The earliest investigation by J. V. HULTKRANTZ (1897) dealt with conscripts from Ångermanland, Medelpad, and Jämtland.

In 1897 and 1898, C. M. FÜRST and G. RETZIUS examined two annual contingents of conscripts from all over the country. The results were published in 1902 under the title *Anthropologia suecica.* The data, however, were not published in such a way that they could be used for a detailed anthropological analysis. Later I. FLODSTRÖM (1926) revised the primary material with regard to some of the racial characters and studied the distribution in jurisdictional districts and assize divisions. The characters, which he used were cephalic index, stature, relative length of legs, length of trunk, and pigmentation.

It is very difficult to compare FLODSTRÖM's results with those of other investigators because he gave distributions only. He included only conscripts whose parents were both born within the same assize division or jurisdictional division. This made the material more representative for the original population from each geographical area. However, at the same time it became insufficient for supplying a detailed picture of the regional variations in certain districts. The more detailed existant anthropometrical maps of the country are, however, based in large part upon FLODSTRÖM's privately printed *Skilda antropologiska typer inom Sverges landsbygdsbefolkning, härads-(tingslags-)vis* (1926). Most of this mapping was later made by LUNDMAN (1940) who, however, repeatedly warns of uncertainties implicit in the method, especially with regard to pigmentation.

In 1922 and 1923, conscripts were examined by the staff of the State Institute for Human Genetics under the leadership of LUNDBORG and LINDERS (*The Racial Characters of the Swedish Nation,* 1926). The treatment of the data was essentially similar to that of the previous investigation by FÜRST and RETZIUS.

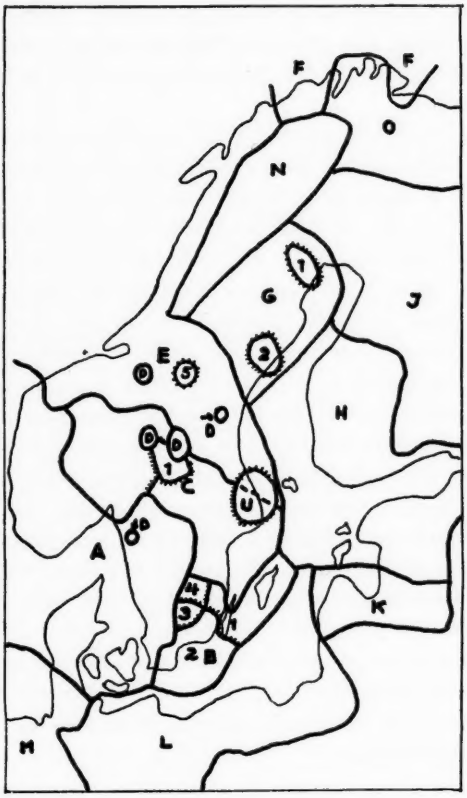
Dalecarlia is the only county in Sweden which has been subjected to a special investigation (LUNDMAN, 1945). LUNDMAN studied the local types of Dalecarlia, and believed that primary groups could be distin-

guished which represent important main categories in the regional anthropology of Scandinavia. LUNDMAN emphasizes the dark dolichocephalic individuals in the forest villages of northwestern Dalecarlia as the oldest elements. This type, the Tydal type (or the Tydal race), occurs, according to LUNDMAN, within several disconnected areas in the interior of the Scandinavian Peninsula. Related types are said to exist in the mountainous districts of the British Isles, as well as scattered in western Europe and as far south as the Canary Islands. Regarding this human type, some remarks about the existence of a probable connection between Cro-Magnon Man and the Nordic race may be mentioned.

Various workers have given descriptions of cromagnid types from France, Italy, Spain, Northern Africa, Germany, Norway, etc. After a study of the literature (among others, the Anthropologia suecica), PAUDLER (1917—18 and 1924) claimed to have established the occurrence of a fair Cro-Magnon race with its centre in Dalecarlia in Sweden, and of a dark Cro-Magnon race in the Iberian Peninsula and among the Berbers of northern Africa. SALLER (1925) doubted whether the frequent finds of Cro-Magnid remains could be attributed to a single racial group, the divergences being too great. Later, HOOTON (1925) put forward a theory that all tall, broad-faced dolichocephalics were mixed types, and might not constitute a racial group in the proper sense of the term. The tall stature might be interpreted as an expression of luxuriance. LUNDBORG and LINDERS (1926) adopted this idea, and considered the Cro-Magnid-like elements in Dalecarlia as a type which might possibly be a mixture of Nordic and East-Baltic races. BACKMAN (1927) objected to this view, and declared that there was no basis for assuming a Nordic-East-Baltic mixture, and that the type may be simply an extreme variant of the Nordic race.

LUNDBORG has subjected the Swedish Lapps to detailed anthropometric examination. His results were published in 1941 by DAHLBERG and WAHLUND.

In 1946 B. LUNDMAN made an analysis of the racial geography of Baltoscandia according to modern biogeographical methods. Data concerning five characters, viz. cephalic index, stature, color of eyes, height-length index, and frequency of the blood group allele B, have been combined in the form of a cline map. The population was divided into "stocks" — LUNDMAN's term for the main subpopulations within Baltoscandia. (See Map 2. For more details of the classification, see LUNDMAN, 1946, p. 24.) The symbol after the names of each stock refers to the corresponding symbol on his map.



Map 2. Division into main subpopulations, based on anthropometrical data (after LUNDMAN).

1. *The stock of southwestern Scandinavia* (A) has low skulls and more clearly blue eyes than the other Nordic populations. The predominant type is called the Göta-type.
2. *The region of southeastern Sweden* (B) is designated as a mosaic region without uniform character.
3. *The stock of the Scandinavian inland* (C) is dolichocephalic, fair, and relatively short. The face is broad and the nasal bridge profile frequently concave.
4. *The Tydal group* (D) is characterized by a stature and a cephalic in-

dex similar to the preceding group, but with a darker pigmentation. The nose is broad and blunt and the face broad. Two localities in Dalecarlia, one in the county of Gävleborg, and one in Bohuslän have been mapped.

5. *The stock of Trøndelagen* (E) is, according to LUNDMAN, a Nordic "alpine" bipolar complex with a high stature, and breadth-length index and height-length index greater in the case of the Scandinavian inland (3). The eyes are light-colored and usually grey.
6. *The stock of Västerbotten* (G) is a rather irregular complex with isolated groups which are sharply delineated. Stature, cephalic index, and eye-color are relatively "Nordic". In this stock narrow faces and blue eyes are commoner than in the stock of Trøndelagen.
7. *The East-Finnish stock* (J) is exemplified by the sub-stock from northern Österbotten. Stature low, cephalic index high and pigmentation generally fair. This stock is said to have a rather high skull and a fairly high frequency of the blood group allele B.
8. *The south Lappish stock* (N) shows high, broad skull, broad face, low stature, and, according to LUNDMAN, a "Scandinavian" distribution of the blood groups, i.e., the high B-frequency characteristic of the Finns is missing. LUNDMAN distinguishes three Lappish substocks in different provinces:
   a. *Jämtland:* Of low stature, dark, but not as brachycephalic as the Lapps from Norrbotten.
   b. *Västerbotten:* Of very low stature, with shorter skulls, and fairer than the preceding.
   c. *Norrbotten:* Pronouncedly brachycephalic and dark, somewhat taller, and more powerful build.

The work referred to above has been treated here at such length because it must be considered, at least for our investigation, the most important and comprehensive survey of the physical anthropology of Sweden. A more critical evaluation of LUNDMAN's work will be made in connection with the discussion of the results of this investigation.

B. SEROLOGICAL INVESTIGATIONS

1. AB0-blood groups

Since the discovery of the AB0-system, serology has steadily undergone a lively development. When larger amounts of data began to

accumulate, obvious differences became apparent in the blood group frequencies of the various groups of people. BOYD (1939) and LUNDMAN (1948) have published maps showing the distribution patterns of the AB0-genes over the world.

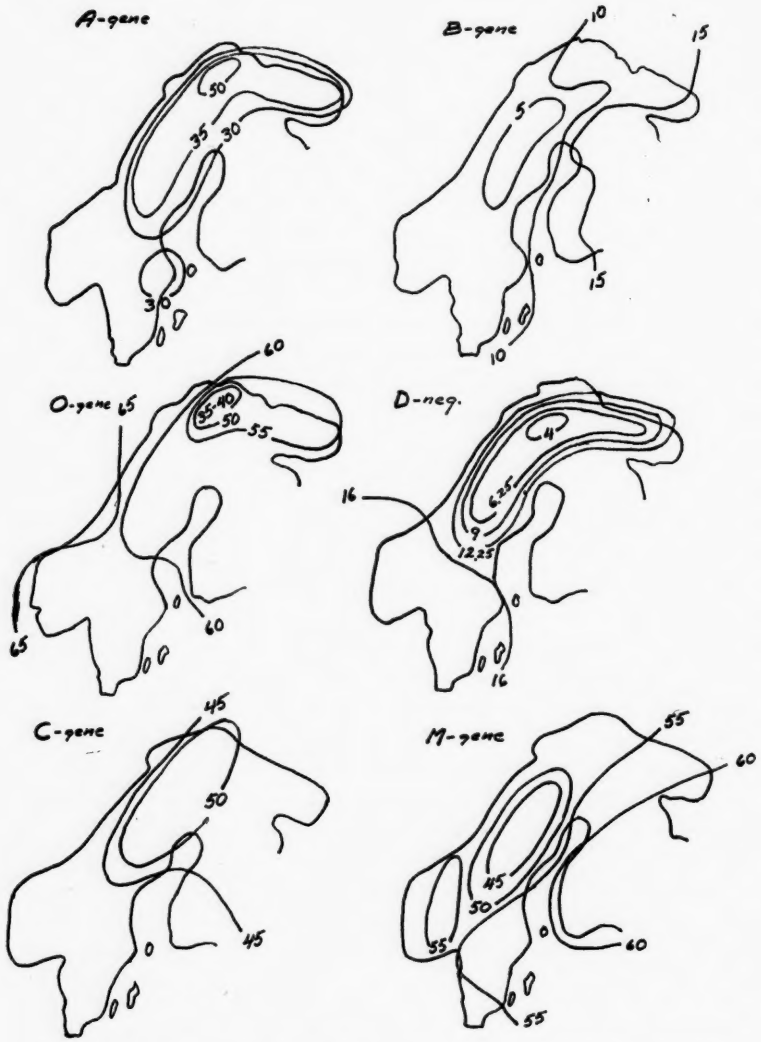
Perhaps the most striking feature in the geographical variation of the AB0 blood groups is the Asiatic maximum of the B-gene which gradually decreases in frequency towards the peripheral regions. Thus, in Europe, the decrease of the B-gene towards the west is the most typical feature of the distribution, a feeble increase in frequency in the most westerly parts is however found.

The A-frequencies in Sweden are, according to BOYD (1939) higher than 30 per cent, and the B-frequencies lower than 10 per cent. It is worthy of mention that on BOYD's maps the concept emerges that the Baltic Sea together with the Gulf of Bothnia represents a sharp serological boundary for B-frequencies.

The most recent synthesis of anthropological blood group studies is *"The distribution of the human blood groups"* by MOURANT, published in 1954. AB0- and MN-data which had already been compiled by BOYD are not included in the tables of this work but taken into account in the text and maps. MOURANT's maps of Sweden 1954 (in the maps of Europe) show the main features of variations within the country according to the material available at the time. Taking into account this limitation his generalizations are substantially correct (cf. Map 3). BECKMAN (1957) has given a preliminary report on AB0 blood groups from northern Sweden. MOURANT (1958) has revised the maps of Sweden (in the maps of Europe) partly based on unpublished data in this study.

For the northern part of the Scandinavian Peninsula MOURANT has given maps for several systems of blood groups, based mainly upon three investigations (ALLISON et al. 1952, 1956) on Norwegian and Swedish Lapps. The numbers of persons examined are fairly small — 183 Norwegian and 346 Swedish Lapps (distributed into two series) — and for this reason the maps must be considered as approximations. No doubt exists, however, that these investigations, which included a great number of serological characters, have clearly demonstrated the special position of the Lapps with regard to the blood group frequencies.

Values for 0 exceeding 60 per cent have been found all over the country south of the county of Västernorrland. The northern part of the country has 0-values between 55 and 60 per cent. The corresponding region in northern Norway which possesses the maximum incidence



Map 3. Distributions of blood group genes A, B, 0, C, D and M in Sweden (after MOURANT).

of A has a minimum for 0. Values approaching 65 per cent have not been found in the Swedish inland and occur on the Scandinavian Peninsula only in Trøndelagen (in Norway). (Map 3.)

2. Rh blood groups

According to FISCHER, the Rh-system is based on three very closely linked loci DCE. On account of the lack of balance, WIENER considers rh as one locus with multiple antigenic effects. Certain combinations are very rare. Thus, CdE has been found only a few times. In Sweden the mapping of the D-gene was based on 5 series from central and southern Sweden and on 2 series of Lapps.

For Sweden only three series have been published which have been tested with anti-C, -D, and -E — one by BROMAN, and the two above-mentioned Lapp series. One of the latter has furthermore been tested with anti-c, -e, -C+C^w, and -C^w.

MOURANT's map of the variation of D-negative frequencies shows a pronounced maximum for the D-gene in northern Scandinavia. Lapland is located inside the isarithm for 6.25 per cent of Rh-negative individuals. The isarithm for 16 per cent runs north of Dalecarlia.

On the basis of the three mentioned series tested with anti-C, -D, and -E, MOURANT (1954) made approximate maps of the E- and C-genes. The frequency of the C-gene is, in northern Sweden, 50—60 per cent, and in southern Sweden 40—45 per cent, whilst the frequency of the E-gene for the entire country is 15—20 per cent.

The Rh-system is characterized by a selection against the heterozygotes especially Dd. This kind of polymorphism is transient.

Most of the workers in anthropological blood group research seem to have adopted FISHER's theory of the Rh-blood groups and use FISHER's notation (e.g., MOURANT, 1954). The author has used the same notations and treatment of the Rh-data. This is made for the sake of comparison without taking up any position in the scientific discussion between WIENER and FISHER concerning the true nature of the genetics of the Rh-factors.

3. MNSs blood groups

Most anthropological investigations have been carried out using only anti-M and anti-N. The M- and N-frequencies vary less than, for example, the frequencies of the AB0 blood groups. The majority of the

examined populations in the world have between 50 and 60 per cent of the gene M. Mourant's isogene map of Scandinavia shows that here, too, the Gulf of Bothnia forms a boundary. The highest M-values of Eurasia are found on its eastern, the lowest on its western side. Lapland has 40—50 per cent, the central part of the country 55—60 per cent, and the southern part somewhat lower frequencies, 50—55 per cent. The mapping is based upon four series. A large series (n=4,000), by WOLF (1946), gives 58.04 per cent of the M-gene. Mapping of the lower frequencies in Scania is based on a series of 1,368 individuals (GRUBB, 1953). The frequency of the gene M was 55.37 per cent. Two series from Swedish Lapps have been recorded (ALLISON et al., 1956). Among 153 Lapps from Vittangi the frequency of M was 44.77 per cent, and for 193 Lapps from all over the county of Norrbotten, 38.6 per cent. In the Norwegian Lapps (ALLISON et al., 1952) the frequency of M is higher (above 50 per cent). The frequency of the gene S is high among Lapps. The frequency of the NS-chromosome in both Norwegian and Swedish Lapps is among the highest in the world.

4. P blood groups

In young individuals the P-positive reaction may be only feebly developed. MOURANT (1954) is of the opinion that much published P-data contain important errors of determination, and that no certain differences have been found in Europe, except for the lower frequency of P among the Swedish Lapps. High P-frequencies have been found in Africa and Asia.

A sample from the total population figures for Sweden, published in 1947 by JONSSON, contained 23.69 per cent of P-negative individuals (n=1,089), which is equivalent to a frequency of the gene P of 51.33 per cent. The series from Swedish Lapps (ALLISON et al., 1956) contained 39.90 per cent of P-negative persons (frequency of gene P=36.84 per cent). In this work the old P-nomenclature has been used. Concerning new nomenclature see RACE and SANGER (1958).

5. Serological anthroposystematics

BOYD (1950) made a race classification based on serological data and distinguished six different races: 1) Early European, 2) European, 3) African, 4) Asiatic, 5) American Indian, and 6) Australoid. Of these groups traces of only three can be discerned in the Swedish population — Early European, European, and Asiatic.

The *Early European* race is characterized by a high per cent of Rh-negatives, a very low B-frequency, a relatively high A_2-frequency and a low M-frequency. This group is thought to be represented by the Basques. The Berbers also reveal characteristics similar to some extent. The Early European group probably has some connection with postglacial Cro-Magnon Man. The connections between the Berbers and the population of the Swedish province Dalecarlia have, as previously mentioned, been discussed by several anthropologists. The Swedish Lapps though genetically distinct show some of the typical characters for Early Europeans in extremely high degree (low B, high A_2 and low M). The low frequency of Rh-negatives is not in accord with BOYD's description of Early Europeans.

The *European* race is characterized by a relatively high frequency of Rh-negatives, a relatively high A_2-frequency, and intermediate frequencies of other genes. In the eastern part of the area, which, according to BOYD, is inhabited by the European group, a rise in M-frequencies can be noted (more than 65 per cent among Finns and Latvians).

The *Asiatic* race is characterized by a high frequency of A_1 and B and a low frequency of Rh-negatives. BOYD describes the M-frequency as intermediate. (It must, however, be considered higher than in Early European and European.) BOYD also uses the phenotypical ratio $\frac{A_2}{A_1}$ as a systematic character for delineation of the Early European group which was said to have an index around 0.5.

6. The change of blood group frequencies

In earlier times blood groups were thought to be neutral to natural selection. Then the only possible explanation of the blood group variations of the world would be genetic drift. After the discovery of a possible selective value in the AB0-system by AIRD, BENTALL, and FRASER ROBERTS (1953) and subsequent work by other research workers (cf. MCCONNELL, 1957) it is now thought that blood group frequencies, like external characters, are altered by natural selection. MOURANT (1956) has discussed the change of gene frequencies due to selection. He points out that when selection may alter the gene frequencies of different haemoglobins within a few hundred years, the AB0 blood groups may respond to selection in periods of the order of two thousand years. Some of the other blood groups may, however, be stable over still longer

periods — longer than for most of the external characters used in physical anthropology.

The discoveries of selective values in the blood groups do not, however, exclude the possibility of genetic drift being an important source of frequency variations.

The most important source of frequency variation is undoubtedly migration. During the last millenia human populations have shown a rapid increase of size and a tremendous mobility. MOURANT (1956) stated: "In general it may be said that where history shows populations to have a common origin they do have similar blood group frequencies."

IV. THE AUTHOR'S INVESTIGATIONS

The results of this investigation are treated in two different sections. In the special section a comparative analysis of the variations within the eleven main regions is carried out. In the general section all available material is compiled into isarithmic maps for the whole country and their bearing on the anthropology of Sweden is discussed.

A. MATERIAL AND METHODS

1. Material

The material for this investigation has been derived mainly from three sources:

a) Determinations of blood groups in the Armed Forces.

b) Blood donor campaigns sponsored by the Swedish Red Cross.

c) Determinations of blood groups made in paternity cases at the Blood Group Serological Department of the State Laboratory for Forensic Chemistry, Stockholm.

a) THE CONSCRIPT MATERIAL

Information about the determinations in the Armed Forces have been obtained partly from the military hospitals, and partly from the rolls in the personnel divisions of the different regiments. (In certain regiments information about the parish of birth was recorded whereas in other regiments this was not included; in such cases I consulted the rolls, which always contain information about the parish of birth.)

b) THE BLOOD DONOR MATERIAL

The data from the blood donor campaigns in the different counties have been obtained from the various sections of the Red Cross. Each individual has been registered in accordance with his place of residence. In some cases compilations of the data by parishes in the form of tables were received. In others the data of each individual was on index cards.

The first blood donor campaign took place in the county of Malmöhus in 1952. The result was published in 1953 by WILLERT and WINBLAD.

c) THE PATERNITY MATERIAL

Blood group determinations in connection with paternity cases have been recorded at the Blood Group Serological Department, State Laboratory for Forensic Chemistry. Such official ledgers may not be removed from the Department; therefore, through the courtesy of the Head of the Blood Group Serological Department, Professor B. BROMAN, the material for the years 1948—56 was microphotographed. In no cases have children been included in this investigation. Each individual has been registered in accordance with his place of residence. This was done in certain regions according to a previously decided regional classification. (See chapter on regional classification.)

The further utilization of this material is difficult because no uniform method has been used for entering the information about the place of residence. In some cases the home parish is entered, in others the name of the village or town.

2. Testing methods

a) THE CONSCRIPT MATERIAL

Official communication No. 10, 1946, of the Military Health Service (Försvarets sjukvårdsförvaltning), contains instructions regarding examination of the blood groups of Armed Forces' personnel. The examination, it is stipulated, shall comprise a control of both red cells and serum. In cases with an uncertain result 5 ml venous blood are to be sent to the State Laboratory for Forensic Chemistry for further investigation. Additional detailed instructions are contained in the official communication of the Military Health Authorities (Försvarets sjukvårdsstyrelse) No. 4, 1954. Previously test-sera had been obtained through the State Bacteriological Laboratory. Now the sera are supplied by the State Laboratory for Forensic Chemistry. The data have in most cases been obtained from conscripts who have served after 1947. For this reason, the material may be considered rather reliable from the point of view of the determinations. In the northern counties, with their large areas and scanty populations, older yearly contingents have also been included. There is understandably a strong tendency to differentiate in the ethnological study of blood groups between the results of determina-

tions in the military services and those carried out by specially trained people at the serological laboratories. It must, however, be stressed that present-day methods for determining the blood groups of conscripts in Sweden are generally reliable enough to be used with confidence for the detection of major group differences. Existing anomalies in the composition of the material may be measured, and less reliable series excluded. The conscript material permits classification according to parish of birth — not only according to the place of residence — in contrast to such records as have been kept for blood donors. This increases the value of the military material from the point of view of regional representation.

b) THE BLOOD DONOR MATERIAL

During the different blood donor campaigns the AB0-determinations have, as a rule, been carried out in the laboratories of the hospitals of individual counties. The determinations from the blood donor campaigns in Jämtland county, however, were all made at the State Laboratory for Forensic Chemistry in Stockholm. In all cases, serum control was included in the AB0-determinations. Commercial sera were used.

In laboratories in different parts of the country only an agglutination test with anti-D has been carried out. As a rule, an anti-D of blocking type was used, a saline-enzyme method with papain as enzyme being employed. The test sera were obtained from the State Laboratory for Forensic Chemistry in Stockholm. Blood which had been found to react negatively was sent to the Rh-laboratory for control with anti-CDE. The final classification into Rh-negatives and "partials" has thus been carried out in Stockholm under the supervision of Professor BROMAN.

c) THE PATERNITY MATERIAL

A_1A_2B0. The determinations were carried out with both serum control and absorption. Good A_2-reagent (anti-H) was obtained from the eel.

MN. The determinations were made by agglutination tests with two different M- and N-sera, and by absorption.

Rh. The determinations were made with saline-enzyme agglutinating anti-C+C^w, -D, and -E.

The *P*-determinations were carried out according to JONSSON's method (see RACE and SANGER, 1950, pp. 74—76). The samples from the paternity cases have been tested more thoroughly than almost any

other P-material. Credit for the existence in the country of this technically exceptional material is entirely due to Dr. JONSSON. Furthermore, since the data for the children, with their feebler P-reaction, have not been included in this investigation, the material can be regarded as the best possible for population genetics.

3. Statistical methods

The material has been distributed primarily in small samples. By combining these first divisions, larger regional samples have been obtained. For these final regional samples the frequencies of the genes were calculated. The differences between observed and expected frequencies have been tested by the χ^2-method.

The significance of the regional variation between the subregions and different main areas was measured by calculating heterogeneity-χ^2 according to the formula:

$$\chi^2 = \frac{1}{\bar{p} \cdot \bar{q}} \left(S(ap) - n\bar{p}\right);$$

where $\bar{q} = 1 - \bar{p}$ (FISHER, 1954).

a) ABO BLOOD GROUPS

The frequencies of the three genes, A, B, and 0, have been calculated by the formulae

$$p = 1 - \sqrt{\bar{B} + \bar{0}}$$

$$q = 1 - \sqrt{\bar{A} + \bar{0}}$$

$$r = \sqrt{\bar{0}}$$

where $\bar{A}$, $\bar{B}$, and $\bar{0}$ are the frequencies of the different blood groups in the population.

BERNSTEIN (1930) gave a simple method for the correction of the frequencies of the genes. The results obtained thereby differ only slightly from those obtained with FISHER's maximum likelihood method. The corrected values pc, qc, and rc for p, q, and r are calculated by means of the formulae:

$$p_c = p\left(1 + \frac{D}{2}\right);$$

$$q_c = q\left(1+\frac{D}{2}\right);$$

$$r_c = \left(r+\frac{D}{2}\right)\left(1+\frac{D}{2}\right);$$

where $D=1-(p+q+r)$.

In the maps and the tables the values for the gene frequencies are given in per cent.

The genetical reliability of the series has been tested according to a formula proposed by STEVENS (1950):

$$\chi^2 = 2\,n\left(1+\frac{r}{p\cdot q}\right)\cdot D^2 \text{ (one degree of freedom)},$$

where $D=1-(p+q+r)$.

The occurrence of less reliable series must be considered in the mapping. Significant differences from the expected values may arise from errors in the serological determination, in the sampling or both. Military determinations of the blood groups are commonly considered inferior in serological technique to those made during a blood donor campaign or in paternity-cases. While military determinations are no doubt inferior from a technical point of view, they may, on the other hand, be regarded as far superior from the point of view of sampling.

For the calculation of A_1A_2B0-frequencies the following formulae have been used:

$$p_1 = 1-\sqrt{\bar{0}+\bar{A}_2+\bar{B}+\bar{A}_2\bar{B}};$$

$$p_2 = \sqrt{\bar{0}+\bar{A}_2+\bar{B}+\bar{A}_2\bar{B}}-\sqrt{\bar{B}+\bar{0}};$$

$$q = 1-\sqrt{\bar{0}+\bar{A}}$$

$$r = \sqrt{\bar{0}}$$

The corrected values have been calculated by means of the following formulae:

$$p_{1c} = p_1\left(1+\frac{D}{2}\right);$$

$$p_{2c} = p_2\left(1+\frac{D}{2}\right);$$

$$q_c = q\left(1 + \frac{D}{2}\right);$$

$$r_c = \left(r + \frac{D}{2}\right)\left(1 + \frac{D}{2}\right);$$

b) RH BLOOD GROUPS

For series which have been tested with anti-D only, the frequency of the gene d was calculated as

$$d = \sqrt{\bar{d}\bar{d}};$$

where $\bar{d}\bar{d}$ is the frequency of D-negative cases.

The frequency of the gene D then becomes $= 1 - \sqrt{\bar{d}\bar{d}}$.

No reliability test is possible. When testing with anti-C and -E the frequencies of the genes C, c, E, and e are calculated in an analogous way.

Of the eight possible chromosome combinations, two (CDE and CdE) are so rare that they may be disregarded in calculations of chromosome frequencies. By doing so the calculations may be simplified. The method described by MOURANT (1954) has been used.

c) MN BLOOD GROUPS

The frequencies of the genes M and N were calculated by means of the following formulae:

$$M = \frac{2\bar{M}\bar{M} + \bar{M}\bar{N}}{2n};$$

$$N = \frac{2\bar{N}\bar{N} + \bar{M}\bar{N}}{2n};$$

For testing the agreement between expected and observed frequencies, the following formula has been used:

$$\chi^2 = \frac{n\,(MN^2 - 4 \cdot MM \cdot NN)^2}{(2\,MM + MN)^2 \cdot (MN + 2\,NN)^2} \quad \text{(one degree of freedom)},$$

where MM, MN, and NN designate the numbers of observed genotypes. The formula was given by FISHER (cf. RACE and SANGER, 1950).

d) P BLOOD GROUPS

The frequency of the gene p was calculated as

$$p = \sqrt{\bar{p}\bar{p}},$$

where $\bar{p}\bar{p}$=frequency of P-negative individuals. The frequency of the gene P=1—$\sqrt{\bar{p}\bar{p}}$. The genetical reliability cannot be measured.

e) HETEROGENEITY

In testing the regional heterogeneity for the genes A, B, and 0, the frequency of the A+AB-individuals has been used to measure the variation of the gene A, the B+AB-frequency for that of the gene B and the 0-frequency for that of the gene 0. The frequency of A_2+A_2B was used to measure the variation of the gene A_2. In the Rh-system the variation was tested by using the relative frequencies of C-, D-, and E-negative persons, and in the P-system by using the frequency of P-negative individuals. In the MN-system the heterogeneity of the genes M and N was tested by the ratio $\frac{2\,MM+MN}{2\,n}$. As the heterozygotes can be distinguished here, it is possible to analyse directly the frequency of the genes.

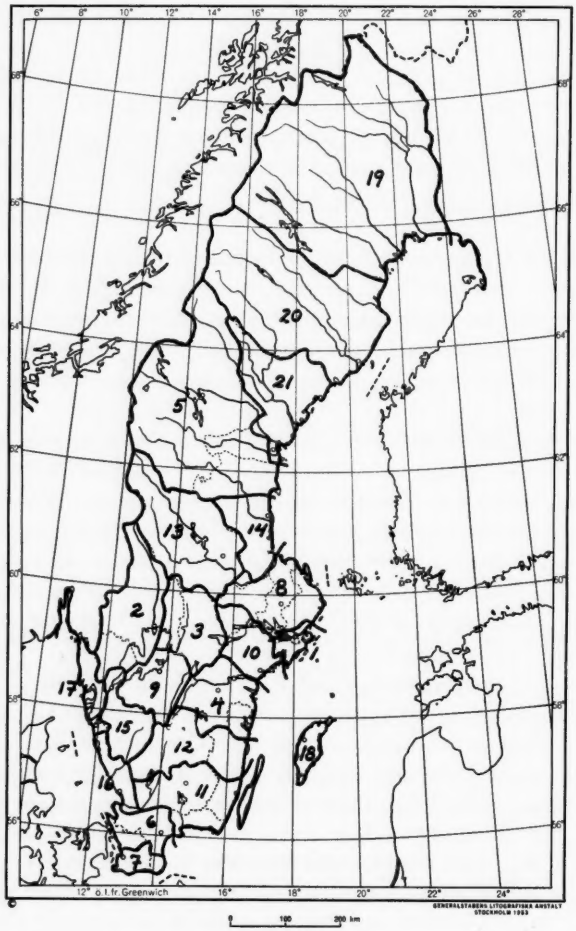
In testing the regional heterogeneity between different samples the limit of significance has been regarded as P=0.02. When testing the consistency of the material, however, a significance limit of P=0.05, has been used.

FRASER ROBERTS (1953) introduced a method of giving the best possible description of the regional variations of the AB0-frequencies by progressive addition of small areas into larger aggregates, and testing for the heterogeneity within and between regions. This method is very valuable when dealing with areas with a small range of variation for certain genes (e.g. the B-gene in England) where large samples and careful examination are needed to find out reliable geographical borders.

In this study, data for some systems obtained from different sources (regionally divided in different ways) have been taken into consideration in the maps which has prevented a pooling and analysis according to the method outlined above. FRASER ROBERTS (1953) stated that for Great Britain it is difficult to draw isogene maps (because of the small variation) and it would be better to separate large areas and give the figures for each area instead. Since in the Swedish material a rather wide range of variation has been found the isogene maps have been considered to be adequate descriptions of the homogeneous and heterogeneous areas of the country.

4. The regional classification

Because of the necessity of treating different blood group data of varying origin and size separately, specific regional classifications for the different series of data have been used. The report has, however, been based on the division of the country into 11 main regions. This regional classification is the same for all materials. It is not claimed



Map 4. Division into conscription areas.

that this classification represents the most suitable one from the point of view of anthropogeography. It is merely a useful classification for the purpose of describing the data and for locating regions quickly by reference to some simple figures.

a) THE CONSCRIPT MATERIAL

Military conscription areas do not always correspond to counties. The units of which conscription areas are composed are the jurisdictional districts. The conscription areas are shown on Map 4. In a number of instances, county and conscription area coincide. In some cases information about the parish of birth was not available, which necessitated giving the data of each military unit as a whole. It must be recalled that in these instances the military unit represents the conscription area, not the county. The symbols of the infantry regiments (i.e. I: 1) correspond to conscription areas on Map 4.

For the main regions I—VI and a part of the main region VII the primary distribution of the AB0 blood groups was made by parishes. An individual investigation of the numerous small parishes in southern and central Sweden would have been prohibitively expensive. With the divisions in southern Sweden, the regional classification underlying the paternity material has been used as far as possible (see below).

b) THE BLOOD DONOR MATERIAL

In some counties investigations covering practically every parish have been carried out, e.g., in Jämtland, whereas in other counties, the blood donor campaign has been restricted to a smaller area, e.g., the region around Luleå in Norrbotten. The material is presented by counties, and where possible, divided still further into sub-regions.

c) THE PATERNITY MATERIAL

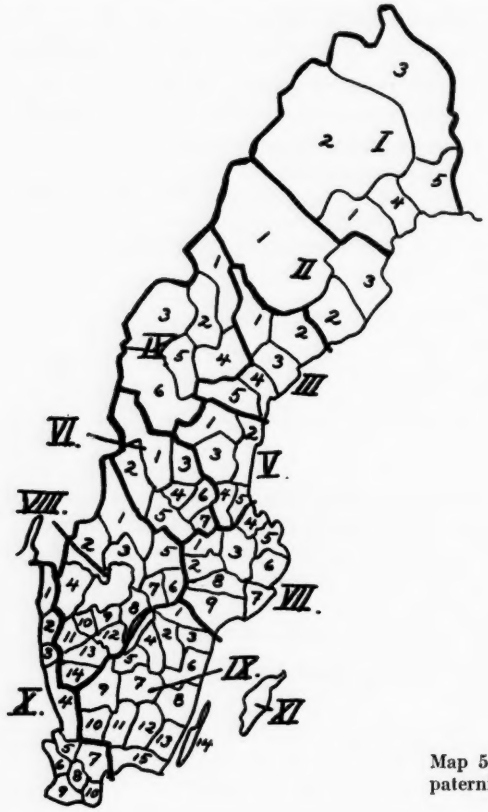
A primary division of the 11 main regions into subregions was made. The unit of the division was the jurisdictional district. The regional division is shown in Map 5. The names of the jurisdictional districts (and assize divisions) entering into the different regions are found in the adjoining table, with the exception of regions I and II (counties of Norrbotten and Västerbotten), where the material has been primarily distributed over parishes.

TABLE 1. *Regional division of the paternity material.*

Main region	Sub-region	Jurisdictional districts and assize divisions
III	1	Ramsele, Resele, Fjällsjö
	2	Nätra, Själevad, Arnäs
	3	Sollefteå, Boteå, Ångermanland s., Nordingrå
	4	Indal, Ljustorp, Skön, Njurunda
	5	Medelpad w.
IV	1	Hammerdal
	2	Lit, Rödön
	3	Offerdal, Undersåker
	4	Ragunda, Revsund-Brunflo, Näs
	5	Hallen, Oviken, Berg, Sunne
	6	Sveg, Hede
V	1	Delsbo, Ljusdal
	2	Bergsjö, Forsa, Enånger, Ala
	3	Arbrå, Järvsö, Bollnäs
	4	Gästrikland w.
	5	Gästrikland e.
VI	1	Särna, Idre, Älvdal, Mora
	2	Malung
	3	Orsa, Rättvik
	4	Leksand, Gagnef
	5	Nås, Västerberg
	6	Falu n. and s.
	7	Hedemora, Folkare
VII	1	Norberg, Skinnskatteberg, Vagnsbro, Övertjurbo, part of Snevringe
	2	Åkerbo, part of Snevringe, Norrbo, Tuhundra, Siende, Yttertjurbo
	3	Åla, Simtuna, Torstuna, Norunda, Bälinge, Vaksala, Ulleråker, Hagunda, Lagunda, Åsunda, Trögd, Håbo, Bro
	4	Örbyhus, part of Oland
	5	Rasbo, part of Oland, Frösåker
	6	Ärlinghundra, Närdinghundra, Lyhundra, Bro, Vätö, Långhundra, Seminghundra, Sjuhundra, Frötuna, Länna, Vallentuna, Åker
	7	Danderyd, Värmdö, Svartlösa, Sotholm, Sollentuna, Färentuna, Stockholm
	8	W. Rekarne, E. Rekarne, Åker, Selebo
	9	Oppunda, Villåttinge, Daga, Öknebo, Hölebo, Rönö, Jönåker
VIII	1	Älvdal, Fryksdal
	2	Jösse, Nordmark, Gillberg, Näs

TABLE 1 (continued)

Main region	Sub-region	Jurisdictional districts and assize divisions
	3	Kil, Nyed, Väse, Karlstad, Grums, Ölme, Visnum
	4	Tössbo, Vedbo, Nordal, Sundal, Valbo
	5	Karlskoga, Grythytte, Hällefors, Nya Kopparberg, Linde, Ramsberg, Fellingsbro, Nora, Hjulsjö
	6	Örebro, Glanshammar, Kumla, Sköllersta, Asker
	7	Edsberg, Grimsten, Sundbo
	8	Vadsbo, Kåkind
	9	Skåning, Valle, Kinne, Kinnefjärding, Kålland
	10	Åse, Viste, Barne, Laske
	11	Väne, Flundre, Bjärke, Ale, Kulling, Vättle
	12	Gudhem, Vilske, Vartofta
	13	Gäsene, Veden, Ås, Redväg, Bollebygd
	14	Mark, Kind
IX	1	Finspångalän, Bråbo, Memming, Lösing, Östkind, Björkekind
	2	Gullberg, Boberg, Aska, Vifolka, Valkebo, Hanekind, Kinda
	3	Åkerbo, Skärkind, Bankekind, Hammarkind
	4	Ydre, Göstring, Lysing, Dal
	5	Vedbo, Vista, Tveta
	6	N. Tjust, S. Tjust, Sevede
	7	S. Vedbo, Östra, Västra
	8	Tunalän, Aspeland, Stranda, Handbörd
	9	Mo, Östbo, Västbo
	10	Sunnerbo
	11	Norrvidinge, Allbo, Kinnevald
	12	Konga, Uppvidinge
	13	N. Möre, S. Möre
	14	Åkerbo, Slättbo, Runsten, Algutsrum, Möckleby, Gräsgård
	15	Östra, Medelstad, Bräkne, Lister
X	1	Vette, Tanum, Bullaren, Sörbygden, Kville, Tunge, Sotenäs, Stångenäs
	2	Lane, Inl. Fräkne, Orust w., Orust e., Inlands Torpe, Inlands Nordre, Inlands Södre, Hisings
	3	Göteborg, Askim, Sävedal
	4	Fjäre, Viske, Himle, Faurås, Årstad, Halmstad, Tönnersjö, Hök
	5	Bjäre, S. Åsbo, N. Åsbo
	6	Luggude, Onsjö, Rönneberg, Harjager
	7	E. Göinge, W. Göinge, Villand, Gärd
	8	Frosta, Färs
	9	Torna, Bara, Oxie, Skytt, Vemmenhög, Ljunit, Herrestad
	10	Albo, Ingelstad, Järrestad



Map 5. Regional subdivisions in the paternity material.

B. SPECIAL SECTION

1. Main region I. The county of Norrbotten

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

This main region contains in addition to the Swedes Lappish and Finnish elements.

Though a number of anthropometric surveys exist, the racial analysis of Norrbotten cannot be considered complete. Apart from FLODSTRÖM's work and the information in *The Racial Characters . . .*, a previously mentioned special study (LUNDBORG, DAHLBERG, and WAHLUND, 1932—1941) has been made of the Lapps. For Lappish men aged 25—50, the following data are available from the counties of Norrbotten, Västerbotten, and Jämtland.

TABLE 2. *Anthropometrical data for Lapps aged 25—50 from the counties of Norrbotten, Västerbotten and Jämtland.*

	Cephalic index	Face breadth, mm.	Stature, cm.	Dark eyes, %	Dark hair, %	n
Karesuando Jukkasjärvi Gällivare Jokkmokk	85.2	143.2	160.4	51	83	110
Arvidsjaur Arjeplog	82.9	140.1	159.3	59	73	70
Västerbotten	82.5	141.4	158.0	38	68	66
Jämtland	81.4	139.5	158.7	63	65	49
All Lapps	83.4	141.4	159.3	52	74	295

Nos. 1—10 of the Martin scale have been classified as light eyes, Nos. 11—16 as dark eyes. Fair hair corresponds to the Nos. 7—26 and 1—3 of the scale of FISCHER, dark hair to the Nos. 4—6 and 27—28.

The frequency of dark-haired individuals increases towards the north, and shows a significant heterogeneity ($0.01>P>0.001$). Eye color presents a lower degree of heterogeneity ($0.05>P>0.02$). Compared with the Lapps of northern Norrbotten, those in the southern part show less pronounced Lappish features.

Northern Sweden contains interesting ethnical components. Often the material is not sufficient for detailed mapping, if the vast magnitude of the area is taken into consideration. To establish a more reliable basis for comparisons of anthropometrical and serological data, an analysis of the anthropometrical data on which LUNDMAN's maps are founded, has been made in the case of the counties of Norrbotten and Västerbotten. The results of the analysis agree in general with LUNDMAN's maps.

For a further reliability control of the anthropometric maps of the three northernmost counties, the primary material in *the Racial Characters of the Swedish Nation* has been rearranged according to parishes. The regional classification was the same as that used for examination of the blood group data of the conscript material (BECKMAN 1956).

Detailed results in the form of tables, available at the State Institute for Human Genetics, are too lengthy for reproduction here. I restrict myself, therefore, to the statement that, on the whole, the results confirm the earlier detailed maps.

It can be stated, further, that the frequency of concave nasal bridge profiles seems to be higher in the northeastern part of the county ($0.02>P>0.01$), and that the lowest frequency is found in the region of Luleå. In Överluleå and Jokkmokk (subregions 3 and 9 in the following classification of the conscript material) the frequency of brown-eyed individuals is lowest, and that of fair-haired and red-haired highest.

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

For 8,163 conscripts from the Norrbotten regiment (I: 19), data concerning blood group and parish of birth have been taken from the rolls. By combining figures for some of the parishes of original distribution, 17 regions have been designated. Older conscript data have also been included, since it was intended to cover the vast county of Norrbotten as completely as possible with regard to the interesting anthropological conditions (e.g., the Lapps). In other cases, wherever possible data from the last 10 years have been used, assuming a continual improvement in determination techniques.

The following regional distribution gives the names of the parishes entering into the subregions. The numbers are found on Map. 6.

Region	Parishes	Region	Parishes
1	Arvidsjaur	10	Råneå
2	Arjeplog	11	Töre, Nederkalix
3	Jokkmokk	12	Överkalix
4	Gällivare	13	Karl Gustav, Nedertorneå
5	Jukkasjärvi, Karesuando	14	Hietaniemi, Övertorneå
6	Piteå, rural community	15	Korpilombolo
7	Älvsby	16	Tärendö, Junosuando
8	Nederluleå	17	Pajala
9	Överluleå, Edefors		

The western regions — the parishes of Lapland — are very large; those in the east comparatively small, with the Lapland regions forming natural geographical units. These also coincide with the natural migration tracks of the respective Lapp groups, in their seasonal herding trips among the intricate systems of lakes and rivers. Subregions 11, 12, 15, and 16 are grouped along the Kalix river, while subregions 13, 14, and 17 are situated along Torne and Muonio rivers.

The distribution within the part regions is shown in Table 3.

The χ^2-test for the consistency of the constituent samples and the total material shows a significant difference for two of the subregions (4 and 8). One of them reveals a surplus of AB, the other a deficiency. If χ^2 alone had been considered for the whole area, the consistency of the material would have been regarded as satisfactory. This illustrates the necessity of conducting a separate examination of the consistency of each constituent sample.

The frequency of A+AB shows a significant heterogeneity ($\chi^2=102.71$, 16 d.f., $P<0.001$).

The frequencies of A vary between 26 and 43 per cent. Two separate areas with a higher frequency of A can be distinguished, viz., a tract farthest north and a southern area (subregion 2). Subregion 3 exhibits lower frequencies, a gap in the otherwise decidedly "Lappish" values. Subregion 3 (Jokkmokk) is the centre of one of the purest Lappish stocks (COLLINDER, 1957). Anthropometrical as well as serological data indicate that in the Jokkmokk population,

TABLE 3. *AB0 blood groups and gene frequencies.*
(Conscript material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	191	46	22	132	391	0.10	32.6	9.1	58.3	99.75
2	98	18	9	44	169	0.86	39.7	8.4	51.9	98.76
3	165	25	10	127	327	0.26	31.9	5.5	62.6	99.67
4	397	74	16	237	724	**14.02**	34.7	6.5	58.8	98.11
5	290	52	21	178	541	1.89	35.0	7.0	58.0	99.16
6	312	84	30	287	713	0.52	27.9	8.4	63.7	99.64
7	177	54	16	179	426	0.66	26.2	8.6	65.2	99.49
8	185	35	31	185	436	**10.19**	28.6	7.8	63.6	101.99
9	310	73	32	217	632	0.47	32.4	8.6	59.0	99.59
10	273	38	25	189	525	0.65	34.2	6.2	59.6	100.46
11	327	78	29	351	785	0.00	26.0	7.1	66.9	100.00
12	280	29	11	237	557	0.29	30.9	3.7	65.4	99.79
13	191	59	29	172	451	0.42	28.4	10.3	61.3	100.46
14	240	75	35	203	553	0.06	29.1	10.5	60.4	100.16
15	124	17	7	74	222	0.78	36.1	5.6	58.3	99.23
16	172	10	8	76	266	2.09	42.9	3.4	53.7	101.02
17	240	39	30	136	445	0.77	37.2	8.1	54.7	100.67
Total	3.972	806	361	3.024	8.163	1.958	29.5	7.8	62.7	99.79

Map 6. Distribution of the A, B and 0 genes according to the conscript material (percentage frequencies).

as represented by samples from conscripts, the Lappish element is weaker than in the other parishes of Lapland. This supports the assumption that here the Lapps have intermingled in lesser degree with the other population. Kiruna with Vittangi has A-frequencies above 40 per cent. Geographically this area is connected with regions 15 and 16, which likewise exhibit high frequencies. Thus it appears that maximum values are gathered around the upper course of the Kalix river.

TABLE 4. *AB0-blood groups and gene frequencies in the town of Kiruna.*

A	B	AB	0	n	χ^2	p	q	r	p+q+r
138	8	6	64	216	0.004	42.3	3.3	54.4	99.95

The AB0-data from Kiruna (see Table 4) are of a typical Lappish distribution, despite the fact that the population of the town is by no means pure Lapps, though this element is considerable. It should be pointed out that Kiruna is not an urban community in the common sense of the word, but comprises several incorporated communities of rural character.

χ^2 for the frequency B+AB shows a significant heterogeneity ($\chi^2=79.16$, 16 d.f., $P<0.001$). Since historical evidence suggests an important Finnish element, high frequencies for B might be expected in Norrbotten. Nevertheless, only subregions 13 and 14 present frequencies for B above 10 per cent. In Norrbotten the Lappish element is probably important, and the Lapps have very low frequencies for B. The B-frequencies of a Lappish—East-Baltic mixed population ought to correspond roughly to the average for Sweden, i.e., between 7 and 8 per cent. A significant heterogeneity for B+AB ($\chi^2=13.29$, 1 d.f., $P<0.001$) exists within subregion 5, which consists of the two parishes Karesuando (in the north) and Jukkasjärvi (in the south). The B-frequency is about 14 per cent in Karesuando (n=85), and as low as 6 per cent in Jukkasjärvi (n=456). The low B-frequencies which may be interpreted as indicating the presence of Lappish elements, are concentrated mainly in the regions along the upper course of the Kalix river, thus in the regions which also exhibit the high frequency for A. The adjoining town of Kiruna shows a low frequency for B. No significant difference in B-frequency exists between the coastal region and the Lappish area. How, it may be asked, is the concentration along the valley of the Kalix river of regions with low frequency for B to be interpreted, if we assume that this region — at least along the lower river course — is not a real Lappish kernel area? Since the Lapps doing military service are very few whatever Lappish traits are remarked in the conscript material must be mainly the result of Lappish intermixture during earlier generations. Thus we should discern the strongest Lappish traits in tracts where the Lapps have been undergoing long-time assimilation, and the feeblest where they have intermingled with the other populations to a smaller extent. It is possible that the upper Kalix valley contains a higher percentage of an old assimilated Lappish population than the typical mountain districts. It is not only the Lapps

who have low frequencies for B, but also other old populations in western Europe. A number of facts, e.g., the high frequency for 0 in the coastal districts of northern Norrbotten, points towards a west European influence there. This may also be responsible in part for the relatively low B-frequencies in the lower Kalix valley; while low B-frequencies in the upper part are probably due to Lappish elements.

The frequency of the 0-group shows a significant heterogeneity ($\chi^2=78.91$, 16 d.f., $P<0.001$), with frequencies varying between 51.9 and 66.9 per cent. Higher values are concentrated mainly in the coastal region, but continue also into region 12 (Överkalix).

ii. *The blood donor material*

The blood donor campaign in Norrbotten county has so far covered only Luleå and the surrounding country.

We have thus, at present, only one sample (cf. Table 5) from the Luleå area. This consists of four-fifths of the town's citizens. The others come from the communities of Nederluleå and Råneå.

TABLE 5. *AB0- and Rh-data from the Luleå area (blood donors).*

A	B	AB	0	n	χ^2	p	q	r	p+q+r	D-	% D-	% d-gene
805	196	127	726	1.854	1.07	29.4	8.3	62.3	100.33	385	20.8	45.6

The χ^2-test shows good agreement between the expected and the observed frequencies. For the AB0-frequencies, agreement with the conscript material is good.

The frequency of D-negative individuals is as high as 20.8 per cent — apparently more than MOURANT's map suggested. The high frequency can hardly be explained as the result of serological errors, since the preliminary grouping, carried out in the hospital at Luleå, was followed by the dispatch of all D-negative samples to Stockholm for control at the State Laboratory for Forensic Chemistry. This high frequency might possibly be associated with south-Swedish influence in coastal area which, for diverse reasons (e.g. relatively high 0), may be assumed. LUNDMAN (1946), in his work Baltoskandia, has assumed the existence of a special Luleå group.

The distribution between the Rh- and AB0-blood groups shows that the frequency of D-negative individuals is higher in the 0-group than in the A-group.

TABLE 6.

	A	B	AB	0	n
Rh +	662	167	115	525	1.469
Rh —	143	29	12	201	385
Total	805	196	127	726	1.854

The frequency of D-negative individuals within the A- and 0-groups shows a significant heterogeneity ($\chi^2=21.44$, 1 d.f., $P<0.001$).

The combination 0, D-negative which is the most suitable for blood donorship has been overrepresented; one is tempted to consider, therefore, whether during the blood donor campaign some kind of selection in favor of this combination has not taken place. The normal AB0-distribution does not fit in with such an assumption, however.

If selection with regard to 0 had taken place, the frequency of 0 should have been higher.

iii. *The paternity material*

From this county there are data for 578 individuals (503 individuals for the Rh-system). The material has been divided into 5 subregions.

The subregions in the foregoing classification of the conscript material that correspond to the subregions in the classification of the paternity material are indicated below.

Subregion	Corresponds to the subregions in the conscript material
1	1, 6, and 7
2	2, 3, and 4
3	4, 15, 16, and 17
4	8 and 9
5	10, 11, 12, 13, and 14

The A_1A_2B0-system

Table 7 gives the gene frequencies for the respective samples, which are all of satisfactory consistency. The most striking feature is the A_2-frequency in the subregions 1, 2, and 3 — unusually high for Swedish conditions (above 17 per cent). Frequencies of 10—11 per cent are found in the subregions 4 and 5. The difference in the frequencies of A_2+A_2B between regions 1—3 and regions 4—5 gives $\chi^2=7.73$, 1 d.f., $0.01>P>0.001$; thus the difference between the coastal area and the inland is significant. A_2-frequencies as high as observed in subregions 1—3 have never been encountered before except in pure Lappish samples. Since our material is a sample of the total population of Norrbotten, the result must be interpreted as indicating a considerable Lappish influence in the population of the Norrbotten Inland. (Cf. the earlier results from the conscript material.) No other reasonable explanation of the high A_2-frequencies seems possible.

The difference between the A+AB-frequencies from regions 1—3 and regions 4—5 gave $\chi^2=2.47$, 1 d.f., $0.2>P>0.1$.

Table 7 shows, furthermore, that the frequencies for the B-gene are highest in regions 4 and 5. This implies an eastern element in these regions; it supports the earlier observation of the conscript material, and, to a certain extent, blood donor study. The lower frequency for A_2 also points to an eastern influence. The difference in the frequencies B+AB between the regions 1—3 and 4—5 gave, however, $\chi^2=3.67$, 1 d.f., $0.1>P>0.05$ which is not significant.

TABLE 7. *A_1A_2B0 groups and gene frequencies.*

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1	29	28	11	4	2	42	116	0.03	15.4	17.0	7.6	60.0	100.21
2	31	28	8	4	2	42	115	0.39	16.6	17.3	6.3	59.8	100.76
3	23	17	5	1	2	25	73	0.02	18.1	17.9	5.3	58.7	99.79
4	50	24	24	3	3	56	160	1.90	18.3	11.2	10.0	60.5	98.34
5	35	14	13	4	4	44	114	0.62	18.8	10.3	9.6	61.3	101.09
Total	168	111	61	16	13	209	578	0.05	17.5	14.2	8.1	60.2	99.87

The Rh-system

The frequencies of the different subgroups can be seen in Table 8.

TABLE 8. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	CE	Rh-	n
1.	48	17	19	1	1	0	0	6	92
%	52.2	18.5	20.6	1.1	1.1			6.5	
2.	49	26	15	2	1	0	0	11	104
%	47.1	25.0	14.4	1.9	1.0			10.6	
3.	37	6	15	0	2	0	0	5	65
%	56.9	9.2	23.1		3.1			7.7	
4.	78	21	23	0	3	0	0	17	142
%	54.9	14.8	16.2		2.1			12.0	
5.	45	17	24	1	1	0	0	12	100
%	45.0	17.0	24.0	1.0	1.0			12.0	
Total	257	87	96	4	8	0	0	51	503
%	51.09	17.30	19.09	0.80	1.59			10.13	

The greatest frequency variation among the different regions is found in the CDE-group which shows no significant heterogeneity ($\chi^2=8.00$, 4 d.f., $0.1>P>0.05$). Between regions 2 and 3 we obtain $\chi^2=6.45$, 1 d.f., $0.02>P>0.01$. CDE-frequencies seem thus to decrease toward north-east. Pure nomadic Lapps seem to have a low CDE-frequency. This, like the AB0-data, suggests a stronger Lappish element in the population of the northeastern part of the county. The frequency of Rh-negative individuals is lowest in regions 1—3, and highest in the coastal area, a predictable result, since the Lapps are known to possess low frequencies. The result of the blood donor campaign in the Luleå area, furthermore, showed a higher frequency of Rh-negative individuals. The difference between coastal region and inland is, however, not significant.

TABLE 9. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1	72.4	27.6	46.8	53.2	22.0	78.0	92
2	66.1	33.9	48.1	51.9	22.2	77.8	104
3	67.1	32.9	44.5	55.5	17.7	82.3	65
4	62.5	37.5	46.9	53.1	16.9	83.1	142
5	63.9	36.1	39.2	60.8	23.2	76.8	100
Total	65.76	34.24	45.21	54.79	20.74	79.26	503

The frequencies for the genes C, D, and E are shown in Table 9. No significant heterogeneity exists for the frequency of C- and D-negative individuals.

The MN-system

The consistency of the material is satisfactory. Throughout the entire area, the frequency of the gene M lies above 61 per cent. This is not in agreement with MOURANT's map which gives the frequency as below 50 per cent, and falling to 45 per cent. The frequency of $\frac{2\,MM + MN}{2\,n}$ shows no significant heterogeneity ($\chi^2 = 4.34$, 4 d.f., $0.5 > P > 0.3$). Since we know that the Lapps have lower M-frequencies, lower frequencies might have been expected in subregions 2 and 3, and higher ones in, for example, region 5. This is not the case. The result seems rather to indicate that an eastern element indicated by a relatively high frequency of M, is distributed throughout Norrbotten county.

It may be asked why does the Lappish influence fail to appear in the form of low M-frequencies in subregions 2 and 3, when the A_2-frequencies show such a distinct Lappish influence? A mixture of a Lappish population having about 40—50 per cent M and a Finnish population having more than 65 per cent M may very well produce about 60 per cent M. If the Finnish element had been predominant, frequencies even higher than the existing ones might have been expected. The Finnish element in Norrbotten county is derived from the East-Finnish stock (LUNDMAN, 1940), who shows about 66 per cent M (MOURANT, 1954). After an introgression, the high frequency of the gene A_2 should survive the low frequency of M, since the difference between Lapps and other populations is considerably greater with regard to the frequencies of A_2.

TABLE 10. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1	39	64	13	116	2.75	61.2	38.8
2	41	50	24	115	1.43	57.4	42.6
3	34	30	9	73	0.58	67.1	32.9
4	62	78	20	160	0.36	63.1	36.9
5	37	59	18	114	0.48	58.3	41.7
Total	213	281	84	578	0.31	61.16	38.84

The P-system

The table shows that the frequency of P-positive individuals is lowest in subregions 2 and 3. The difference between subregions 2—3 and subregions 1, 4, and 5 gave $\chi^2=13.33$, 1 d.f., $0.001>P$. There is thus a significant difference between the coastal and inland areas, as might have been expected, since earlier investigations of the Lapps revealed a lower frequency of P-positive individuals.

TABLE 11. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1	93	80.17	23	19.83	116	55.5	44.5
2	76	66.09	39	33.91	115	41.8	58.2
3	50	68.50	23	31.50	73	43.9	56.1
4	130	81.25	30	18.75	160	56.7	43.3
5	92	80.70	22	19.30	114	56.1	43.9
Total	441	76.30	137	23.70	578	51.32	48.68

iv. *Summary*

A-frequencies are highest in the north-east and the south-west. A_2-frequencies are lowest in the northern coastal area and highest in the inland. B-frequencies are highest in the east and lowest in the valley of the Kalix river. The frequencies of 0 are highest in the coastal area.

The frequency of Rh-negative individuals is high around Luleå but low elsewhere, while the M-frequency is homogeneous and higher than 61 per cent. In the inland the P-frequency is lower than in the coastal area.

2. Main region II. The county of Västerbotten

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

Apart from examinations of Västerbotten conscripts, the county has not been the subject of any exhaustive anthropological investigations. For this, as for many other regions, our knowledge about the variations of certain characters is based mainly upon FLODSTRÖM's tables of 1926, which deal with 1,239 examined individuals distributed over 11 assize divisions. LUNDMAN has put the results in map form.

Detailed analysis of the primary material for *"The Racial Characters ..."* generally confirms LUNDMAN's earlier mappings, which may thus be endorsed as satisfactory material for anthropometric comparison.

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

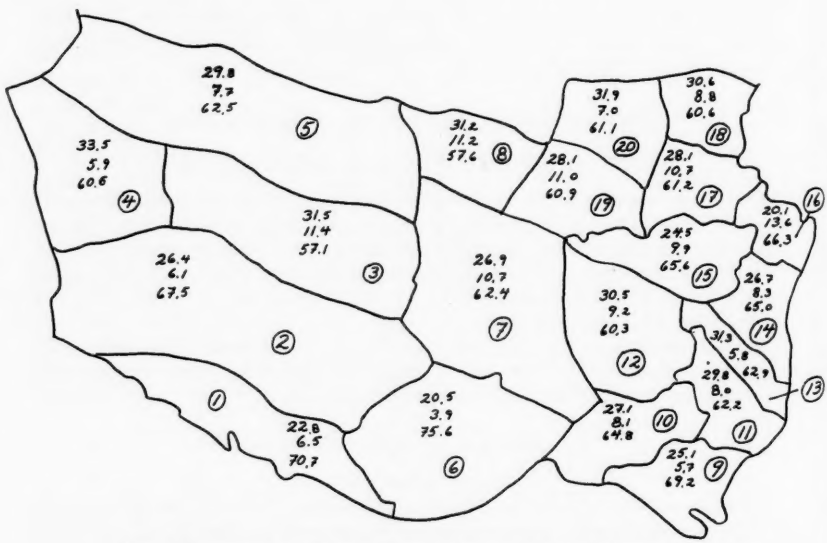
The material comes from the infantry regiment in Umeå (I: 20). Here, as in the case of Norrbotten county, a number of conscripts belonging to classes of earlier years have been included.

In the investigations the following regional classification has been used:

Sub-region	Parishes	Sub-region	Parishes
1	Dorotea	11	Umeå rural community
2	Vilhelmina	12	Degerfors
3	Stensele	13	Sävar
4	Tärna	14	Bygdeå, Nysätra
5	Sorsele	15	Burträsk
6	Åsele, Fredrika	16	Bureå, Lövånger
7	Lycksele, Örträsk	17	Skellefteå rural community
8	Malå	18	Byske
9	Nordmaling, Hörnefors	19	Norsjö
10	Bjurholm, Vännäs rural community	20	Jörn

The numbers of the subregions are found in Map 7.

Because the northern Swedish parishes are so vast, they often coincide with the regions; nevertheless, fusions have been made in some cases. In the more densely populated coastal area the units are smaller; they are often extensive in the forest and mountain regions. The parishes of Lapland are, on the whole, physico-geographical units, typically forming long chains along the valleys of rivers or lakes. Subregions 1, 2, and 6 are to a certain extent separated in the physico-geographical sense from the areas north of them.



Map 7. Frequencies of the A, B and 0 genes. (Conscript material.)

TABLE 12. *AB0 groups and gene frequencies.*
(Conscript material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	94	26	5	121	246	1.12	22.8	6.5	70.7	99.32
2	216	47	11	222	496	2.03	26.4	6.1	67.5	99.31
3	164	58	14	103	339	**7.45**	31.5	11.4	57.1	97.45
4	81	15	2	52	150	**4.33**	33.5	5.9	60.6	97.87
5	131	31	10	107	279	0.91	29.8	7.7	62.5	99.24
6	105	17	6	174	302	0.42	20.5	3.9	75.6	100.27
7	121	46	12	108	287	1.91	26.9	10.7	62.4	98.79
8	72	20	15	57	164	1.70	31.2	11.2	57.6	101.72
9	212	44	9	222	487	**18.48**	25.1	5.7	69.2	98.04
10	262	75	18	246	601	**4.04**	27.1	8.1	64.8	98.65
11	496	123	39	403	1.061	**3.96**	29.8	8.0	62.2	99.17
12	236	62	28	186	512	0.02	30.5	9.2	60.3	99.91
13	133	21	9	106	269	0.05	31.3	5.8	62.9	99.84
14	270	82	17	254	623	**6.58**	26.7	8.3	65.0	98.68
15	202	77	20	219	518	1.42	24.5	9.9	65.6	99.29
16	142	93	22	197	454	0.55	20.1	13.6	66.3	99.51
17	321	115	35	269	740	3.43	28.1	10.7	61.2	98.96
18	162	45	11	118	336	**4.35**	30.6	8.8	60.6	98.34
19	113	39	17	100	269	0.01	28.1	11.0	60.9	100.10
20	89	18	6	65	178	0.62	31.9	7.0	61.1	99.22
Total	3.622	1.054	306	3.329	8.311	**27.59**	27.5	8.6	63.9	99.23

The total material and seven of the constituent areas show a significant inconsistency. The marked deficiency of AB:s indicates that in the above-mentioned areas a tendency toward too low A-gene frequencies and high 0-gene frequencies exists. The B-gene frequency, on the other hand, is less influenced by serological errors of this kind, since the sum of B and AB is, after all, less altered. In spite of the fact that, from a statistical point of view, agreement with the expected values is not altogether satisfactory, the material gives an idea of the large traits of the variation. The less reliable part regions must also, of course, be taken into account in the mapping process.

The heterogeneity χ^2 for A+AB gave 75.82, 19 d.f., $P<0.001$, for B+AB $\chi^2=103.17$, 19 d.f., $P<0.001$, and for 0 $\chi^2=94.99$, 19 d.f., $P<0.001$.

From these data we can perhaps assume the existence of a significant heterogeneity for gene B, but because of the above-mentioned discrepancies with regard to the A- and 0-groups conclusions must be guarded.

Highest values for the gene A were found in subregions 3 and 4, although really high values are not present anywhere in the area. Low values were, however, encountered in two areas, viz. in subregions 1 and 6 in the southern part of the area, and in subregions 15 and 16. (See Map 7.)

The distribution of gene B presents a rather surprising picture. As has al-

ready been remarked, no series with values for gene B above 10 per cent had previously been found in Sweden. In this region 7 adjoining subregions with values about and above 10 per cent are found. The maximum occurred in subregion 16, Bureå and Lövånger. A separate analysis of Bureå gave the following result (Table 13).

TABLE 13. *Analysis of Bureå.*

A	B	AB	0	n	χ^2	p	q	r	p+q+r
54	36	9	62	161	0.43	22.1	15.2	62.7	99.17

The high B-frequency indicates a gene flow from the east. The B-frequency has its maximum at the narrowest part of the Gulf of Bothnia, Kvarken, which in past times may have been an important route for the westward migrations. Finland and the northern part of the county of Västerbotten with higher B-frequencies show obvious similarities. Between the northern and southern parts of the county the difference is sharp. Southwestern Västerbotten (Åsele lappmark) seems to be connected more closely, serologically, with Ångermanland

TABLE 14. *A_1A_2B0 groups and gene frequencies.*
(Blood donor material)

Subregions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1, 6	20	9	7	1	2	63	102	0.06	10.8	6.3	5.1	77.8	100.80
2	29	11	1	2	1	47	91	2.00	18.7	8.5	2.2	70.6	101.36
3	24	11	11	3	2	31	82	0.008	18.1	10.3	10.3	61.3	100.21
4, 5	31	25	7	1	2	22	88	0.47	20.4	22.5	5.9	51.2	98.42
7	56	20	20	4	2	50	152	0.92	22.4	9.9	9.0	58.7	98.31
8, 19	30	14	17	3	9	38	111	0.79	16.0	13.2	13.8	57.0	102.17
9	28	14	7	1	0	56	106	0.47	14.8	8.1	3.9	73.2	99.27
10	34	14	14	0	2	48	112	0.90	16.6	9.1	7.5	66.8	98.50
11	118	46	29	11	8	135	347	0.69	20.7	10.5	7.1	61.7	100.83
12	37	13	18	6	5	45	124	0.04	19.2	8.5	12.4	59.9	100.40
13, 14	38	23	12	4	1	56	134	0.0001	17.2	11.6	6.5	64.7	99.98
15	26	17	11	3	1	34	92	0.12	17.3	12.8	8.5	61.3	99.33
16	19	7	14	2	2	42	86	0.02	13.0	6.3	11.0	69.7	100.24
17	79	26	37	10	9	84	245	0.09	20.1	9.5	12.2	58.2	100.47
18, 20	41	8	17	3	3	36	108	0.20	23.2	6.9	11.4	58.5	98.98
Total	610	258	222	54	49	787	1980	0.330	18.4	10.1	8.6	62.9	100.25

than with Västerbotten county. Even as far west as the parish of Stensele, in Lapland, a B-frequency up to 11.4 per cent was found. It must also be pointed out that the high B-frequencies of the coastal area are coexistant with low frequencies for A and high frequencies for 0. Similar lower A-frequencies are found likewise in the coastal area of Norrbotten. This might be the result of southwestern ethnical influences.

The gene 0 varies between 57.1 and 75.6 per cent. In subregions 1, 2, and 6 the 0-frequencies were over 70 per cent (1,044 individuals). In all three regions the expected and the observed frequencies were in good accord. Subregions 9 and 10, which also possess high 0-frequencies, and which are situated in the southeastern part of the county, reveal, however, notable divergences. There it might be suspected that serological errors have contributed to the rise. 0-frequencies as high as those from the southern part of Västerbotten have been encountered in northern Europe only in the British Isles and in Iceland. Their existence in southern Lapland points to lower degree of Lappish intermixture in the population of southern Lapland.

ii. *The blood donor material*

Through the courtesy of Dr L. JACOBSSON, of the University Hospital of Umeå, I have been able to study the data from 1,980 conscripts tested as blood donors. Since this material consists of annual contingents of conscripts (classified by birth-parish) and was tested also for A_1A_2 it is of greater usefulness than the other blood donor materials. Though the material consists of con-

TABLE 15. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*

(Blood donor material)

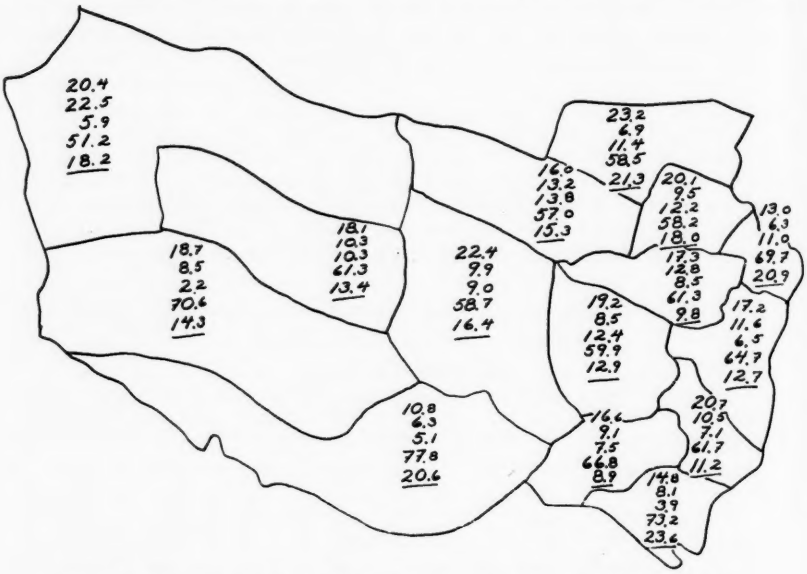
Subregions	D+	%	D−	%	n	D-gene	d-gene
1, 6	81	79.4	21	20.6	102	54.6	45.4
2	78	85.7	13	14.3	91	62.2	37.8
3	71	86.6	11	13.4	82	63.4	36.6
4, 5	72	81.8	16	18.2	88	57.3	42.7
7	127	83.6	25	16.4	152	59.5	40.5
8, 19	94	84.7	17	15.3	111	60.9	39.1
9	81	76.4	25	23.6	106	51.4	48.6
10	102	91.1	10	8.9	112	70.2	29.8
11	308	88.8	39	11.2	347	66.5	33.5
12	108	87.1	16	12.9	124	64.1	35.9
13, 14	117	87.3	17	12.7	134	64.4	35.6
15	83	90.2	9	9.8	92	68.7	31.3
16	70	79.1	16	20.9	86	54.3	45.7
17	201	82.0	44	18.0	245	57.6	42.4
18, 20	85	78.7	23	21.3	108	53.8	46.2
Total	1678	84.75	302	15.25	1980	60.94	39.06

scripts I have included it in the blood donor material to separate it from other conscript data tested only with anti A and anti B.

The division into subregions is the same as for the previous conscript material except that subregions 1—6, 4—5, 8—19, 13—14, and 18—20 have been pooled to make larger samples.

The AB0-system

The agreement between the observed and expected frequencies of A, B, AB and 0 is satisfactory for the total material and all subregions. There is, however, a notable discrepancy concerning the proportions of A_1B and A_2B, the frequency of A_1B being unexpectedly low. Map 8 shows the frequencies of the A_1, A_2, B, and 0-genes and the frequency of D-negatives (underlined figures).



Map 8. Frequencies of the A_1A_2B and 0 genes and Rh-negative individuals. (Blood donor material.)

The frequency of A+AB shows a significant heterogeneity ($\chi^2=44.55$, 14 d.f., $P<0.001$). A very low frequency was found in subregion 1, 6 in the southern part of the county. The agreement with the conscript material is very good (cf. Map 7). The frequency of A_2+A_2B shows a heterogeneity corresponding to $\chi^2=25.93$, 14 d.f., $0.05>P>0.02$. Due to the discrepancies found in the A_1, A_2-distribution conclusions concerning the variation of the A_2-gene must be guarded. Nevertheless the high A_2-frequencies were found where expected, viz. mainly in the north and northwest. Relatively high frequencies were also

found in the central coastal area. The low frequencies may be due to a West European influence.

The frequency of B+AB shows a significant heterogeneity ($\chi^2=46.68$, 14 d.f., $P<0.001$). The agreement with the conscript material is very good which confirms the high B-frequencies in the northern part of the county. This material, also, shows a high B-frequency as far west as subregion 3 (the parish of Stensele).

The frequency of the 0-group shows a significant heterogeneity ($\chi^2=55.33$, 14 d.f., $P<0.001$). Very high 0-gene frequencies were found in the south. In subregion 6, treated separately, there is an 0-gene frequency of 81.9 per cent (n=59), which is the highest 0-value recorded in Sweden. In spite of the small sample this indicates that extremely high values (above 80 per cent) may exist in small pouches in the southern part of Västerbotten county. In the subregion 16 a relatively high 0-frequency is combined with high B-frequency indicating both West European and eastern influences. The same condition was seen in the conscript material.

The Rh-system

The frequency of D-negative individuals shows a significant heterogeneity ($\chi^2=28.18$, 14 d.f., $0.02>P>0.01$). The central coastal area had lower frequencies than the northern and southern parts. This may depend on a Lappish influence (cf. the distribution of the A_2-frequencies). The high frequencies in the northwest (where the A_2-frequencies are highest) do not fit into the general agreement between high A_2—low frequency of D-negatives. This single high value (18.2 ± 3.8 per cent) may, however, be due to chance (Table 15).

iii. *The paternity material*

From this area data have been obtained for 404 individuals (359 with regard to the Rh-system). The material has been divided into 3 part samples. The relations between this division and the regional classification of the conscript material is shown below.

Region	Corresponds to the regions in the conscript material
1	1—8
2	9—13
3	14—20

The A_1A_2B0-system

The consistency of the material is satisfactory. The frequencies of the total A-gene are uniform, lying in all three areas around 30 per cent. The gene A_2, on the other hand, has a lower frequency in subregion 2. The difference between subregion 2 and subregions 1 and 3 corresponds to $\chi^2=6.58$, 1 d.f., $0.02>P>0.01$. Thus the A_2-frequency is significantly lower in the southern coastal area. It appears that the area of Luleå is a separate area with a lower frequency of A_2 (smaller Lappish influence), since the two coastal regions

south of the area of Luleå (region 1 in Norrbotten and region 3 in this area), both possess high A_2-frequencies, and delineate the Luleå area.

No significant differences were found in the B-frequencies. It should, however, be observed that the highest value appears in that area which showed the highest frequencies in the conscript material. For the 0-gene the differences are not significant.

TABLE 16. *A_1A_2B0 groups and gene frequencies.*
(Paternity material)

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1	34	28	13	4	1	53	133	0.07	15.6	14.1	7.1	63.2	99.71
2	51	19	12	4	3	60	149	3.22	20.4	10.2	7.6	61.8	101.98
3	33	26	13	4	2	44	122	0.02	16.6	15.1	8.1	60.2	99.80
Total	118	73	38	12	6	157	404	0.01	17.7	12.9	7.2	62.2	100.07

The Rh-system

As in Norrbotten county, the total material shows a relatively high frequency of the CDE-group. The difference from the general Swedish average is, however, not certain. Within the part regions the frequencies are otherwise uniform, with the exception of Rh-, which in subregion 3 seems to possess a somewhat higher frequency. The difference between subregion 3 and subregions 1 and 2 is, however, not noteworthy ($\chi^2=2.77$, 1 d.f., $0.1>P>0.05$).

TABLE 17. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	Rh-	n
1.	59	24	19	0	2	0	14	118
%	50.0	20.3	16.1	0	1.7	0	11.9	100
2.	66	27	22	1	0	0	15	131
%	50.4	20.6	16.8	0.8	0	0	11.4	100
3.	53	19	13	3	1	1	20	110
%	48.2	17.3	11.8	2.7	0.9	0.9	18.2	100
Total	178	70	54	4	3	1	49	359
%	49.58	19.50	15.04	1.12	0.83	0.28	13.65	100

The frequencies of the genes C, D, and E vary only slightly between the subregions. Also between Västerbotten and Norrbotten counties the variation is inconsiderable. Somewhat lower frequencies for all three genes may perhaps be distinguished in subregion 3, but the difference is not significant.

TABLE 18. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1	63.1	36.9	47.1	52.9	20.3	79.7	118
2	66.2	33.8	46.2	53.8	20.9	79.1	131
3	55.3	44.7	42.0	58.0	16.3	83.7	110
Total	61.58	38.42	45.15	54.85	19.26	80.74	359

The MN-system

The consistentcy of the material is not satisfactory for subregion 3. The frequency of gene M lies somewhat above 61 per cent, resembling the frequencies in Norrbotten. Within the part regions the frequencies are uniform, and no significant difference can be established. Contrary to what might be expected, however, the frequency of M is higher in Lapland than in the coastal region. The higher B-frequencies also extend to the inland regions. These two circumstances point to an eastern influence in the Lappish part of Västerbotten county. It has previously been established that the Lapps from Västerbotten have lighter pigmentation than the Lapps from both Norrbotten and Jämtland — a fact which supports such an assumption.

TABLE 19. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1	57	55	21	133	1.52	63.5	36.5
2	50	80	19	149	1.88	60.4	39.6
3	38	73	11	122	8.14	61.1	38.9
Total	145	208	51	404	3.16	61.64	38.36

The P-system

Here we find the same conditions as in Norrbotten, i.e., a lower frequency of P-positive individuals in the inland, indicating a Lappish element. The difference between subregion 1 and subregions 2 and 3 gave $\chi^2=8.27$, 1 d.f., $0.01>P>0.001$. The region with the least "Lappish" A_2-frequency has here the highest (least "Lappish") P-frequency.

TABLE 20. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1	90	67.7	43	32.3	133	43.2	56.8
2	121	81.2	28	18.8	149	56.6	43.4
3	97	79.5	25	20.5	122	54.7	45.3
Total	308	76.27	96	23.73	404	51.29	48.71

iv. *Summary*

The A-frequency is high in the northern and western and low in the south and east parts of Västerbotten county. The A_2-frequency is highest in the northwest. The B-frequency is high in the northern part of the area, with maximum values toward the east. The 0-frequencies are high in the southern part of the county (above 70 per cent) and in the northeast. The frequency of Rh-negative individuals is high in the northern coastal area and in the south. The frequencies of M are uniform, and lie above 60 per cent. In Lapland the P-frequency is low (cf. the county of Norrbotten).

3. Main region III. The county of Västernorrland

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

The earliest investigations within the area were carried out by HULTKRANTZ (1897). In the southern part of the county (Medelpad), he discovered a difference in cephalic index between the coastal and inland areas. In the coastal area cephalic index is 78.5, according to LUNDMAN's map, whereas it falls below 77.5 inland.

Coastal stature in Medelpad is shorter (0—1 cm) than the average for Sweden. Farther towards the west it rises to 1—2 cm. above the Swedish average. This latter area is geographically connected with the Jämtland area of tall people. An additional tall stature belt exists higher up along the coast, between Nätra and Grundsunda (see the following regional classification), and a fair distance towards the inland. The divergent stature and cephalic index in the southern coastal region may be attributed to eastern influence.

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

The material comes from the infantry regiments in Sollefteå and Östersund (I: 21 and I: 5).

Regional classification:

Subregion	Parishes
1	Haverö, Borgsjö
2	Torp, Stöde
3	Attmar, Tuna, Selånger
4	Njurunda, Skön, Alnö
5	Hässjö, Timrå, Tynderö
6	Indalsliden, Holm, Ljustorp, Indal, Sättna
7	Högsjö, Stigsjö, Säbrå, Hemsö, Häggdånger
8	Graninge, Gudmundrå, Viksjö, Ytterlännäs
9	Ullånger, Skog, Nora, Nordingrå, Bjärtrå
10	Ramsele, Edsele, Helgum
11	Ådalsliden, Resele, Ed, Multrå, Sånga
12	Skorped, Sidensjö, Överlännäs, Boteå, Styrnäs, Dal, Torsåker

Subregion	Parishes
13	Vibyggerå, Nätra, Själevad, Mo
14	Gideå, Arnäs, Grundsunda
15	Anundsjö, Björna, Trehörningsjö
16	Fjällsjö, Junsele
17	Bodum, Tåsjö

This regional classification does not coincide with the physico-geographical areas as well as those in the two more northern counties. Six regions along the coast cover, on account of the greater density of population, somewhat smaller areas than the inland regions.

TABLE 21. *AB0 groups and gene frequencies.*

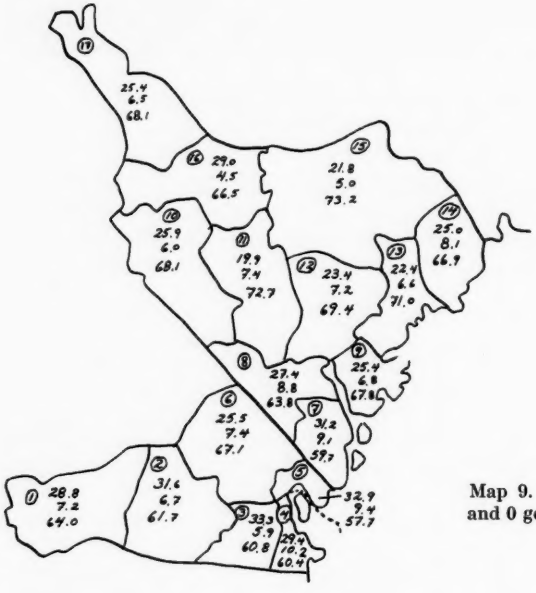
(Conscript material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	89	22	4	75	190	2.87	28.8	7.2	64.0	98.46
2	180	32	16	141	369	0.003	31.6	6.7	61.7	100.07
3	120	14	14	92	240	3.21	33.3	5.9	60.8	101.47
4	230	66	37	197	530	1.36	29.4	10.2	60.4	100.78
5	154	39	16	101	310	0.76	32.9	9.4	57.7	99.21
6	127	32	13	142	314	0.12	25.5	7.4	67.1	100.23
7	165	38	24	130	357	1.06	31.2	9.1	59.7	100.82
8	267	74	33	261	635	0.27	27.4	8.8	63.8	100.28
9	163	40	12	180	395	0.23	25.4	6.8	67.8	99.73
10	156	28	14	177	375	1.74	25.9	6.0	68.1	100.72
11	100	35	9	166	310	0.19	19.9	7.4	72.7	100.46
12	135	39	9	166	349	0.86	23.4	7.2	69.4	99.46
13	195	51	17	270	533	0.13	22.4	6.6	71.0	100.16
14	138	39	15	157	349	0.09	25.0	8.1	66.9	100.19
15	167	34	11	247	459	0.14	21.8	5.0	73.2	100.15
16	119	16	6	109	250	0.94	29.0	4.5	66.5	99.40
17	89	19	9	104	221	0.58	25.4	6.5	68.1	100.56
Total	2.594	618	259	2.715	6.186	1.732	26.6	7.3	66.1	100.20

The composition of the total material and all constituent areas is satisfactory.

The frequency of A+AB shows a significant heterogeneity ($\chi^2=79.28$, 16 d.f., $P<0.001$). The mean value for the A-gene is as low as 26.6 per cent. According to MOURANT (1954), the entire area should have A-frequencies above 30 per cent, with the western part above 35 per cent. Existing values above 30 per cent within the county are all concentrated in the southeast. Large parts of Ångermanland show very low frequencies of A. The kernel area, e.g., subregions 11, 12, 13, and 15, has altogether about 22 per cent. In subregion 11 the value falls to 19.9 per cent. Such low values have been found in Europe

only among original Westeuropean populations, e.g., in the northwestern parts of the British Isles and among the Basques of northern Spain. This result is surprising. No reason exists for doubting its validity, since the serological accuracy seems to be good, and since more than 6,000 individuals have been examined. The existence of relicts of a population of west European origin is possible. The province of Ångermanland can be distinguished from Medelpad.



Map 9. Frequencies of the A, B and 0 genes. (Conscript material.)

With regard to the frequency B+AB, a significant heterogeneity is found (χ^2=42.21, 16 d.f., P<0.001). For the total material, the average value is 7.3 per cent. Maximum values are found in subregions 4 and 5, which together have about 10 per cent. Significant heterogeneity (χ^2=7.01, 1 d.f., 0.01>P>>0.001) exists between subregion 4 and subregion 3, immediately west. Similarities as to changes of cephalic index and stature are notable. Thus, also, the blood group distribution points to certain eastern influences in the coastral area. Subregions 15 and 16, in the north, present the lowest frequencies. This area joins corresponding areas of low frequency in Västerbotten county. In central Ångermanland the frequencies are relatively low and uniform, as are those of the central coastal region.

Within the region we find a significant heterogeneity for the 0-group (χ^2=51.52, 16 d.f., P<0.001). Low values are concentrated exclusively in the southeast. North of the Ångerman river no really low values were found. The

average for the entire county rises to about 66.1 per cent. The province of Ångermanland (subregions 7—17) strongly resembles the southern part of Västerbotten county, and has an average of more than 70 per cent. The 0-frequencies which have been found in this area are reminiscent of the distribution in the northwestern parts of the British Isles and Iceland. Ångermanland and southern Lapland may thus be suspected of containing an ethnic group akin to these areas. HACKETT, DAWSON and DAWSON (1956) suggest that the high frequencies of the 0-gene, found by them, point to a closer relationship between western Ireland and Iceland, which both have high 0-frequencies, than between Iceland and Scandinavia, where the high 0-frequencies, as they occur upon Iceland, should be missing. In Sweden, 0-frequencies exist, however, which fit the Icelandic conditions, and it is possible that a more detailed investigation in Norway would lead to similar results. With regard to the AB0-system, there is thus nothing to contradict a genetic similarity between Scandinavia and Iceland. Cultural links existing between these two areas, furthermore, are so unambiguous that they should remove any doubt regarding the derivation from Scandinavia of the main part of the population of Iceland. The fact remains, however, that Iceland later received immigrants from Ireland.

ii. *The blood donor material*

Through the courtesy of B. VON PORAT, M.D., of the Sundsvall hospital, I have been able to study a valuable collection of 6,472 blood donors. Since the material has been obtained from various small populations — and unlike the conscript material, by parishes — the treatment and mapping had to be made in a different way. The primary material consisted of samples from 36 different places. If, for example, samples from four adjoining places are com-

Map 10. Frequencies of the A, B and 0 genes and frequency of Rh negative individuals. (Blood donor material.)

bined into a larger sample, this latter is assumed to be located geographically in the middle of the four places. The primary material was combined into 16 samples, their approximate geographical positions being shown in Map 10. The large rivers have also been entered on the map and it becomes evident, thus, that the populations are localized partly along the rivers and partly along the coast.

The AB0-system

Consistency of all samples is satisfactory, as is shown in Table 22.

TABLE 22. *AB0 groups and gene frequencies.*
(Blood donor material)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1. Ånge	122	14	10	80	226	0.29	35.3	5.4	59.3	100.45
2. Fränsta, Ljungaverk, Stöde	150	35	14	127	326	0.11	29.6	7.8	62.6	99.75
3. Matfors, Njurunda	196	47	24	141	408	0.003	32.1	9.1	58.8	100.04
4. Sundsvall, Skönsberg, Skön, Selånger, Timrå, Söråker, Alnö	1.056	251	104	929	2.340	0.07	29.0	7.9	63.1	99.93
5. Härnösand	208	47	17	175	447	0.56	29.6	7.5	62.9	99.54
6. Lugnvik, Kramfors, Strömnäs	93	26	15	108	242	2.26	25.4	8.9	65.7	101.25
7. Boteå, Nyland	57	10	6	67	140	1.09	25.7	5.9	68.4	100.92
8. Sollefteå, Långsele, Österåsen	267	67	24	271	629	0.29	26.7	7.5	65.8	99.74
9. Ramsele, Edsele	64	10	6	86	166	1.52	23.9	4.9	71.2	100.86
10. Hoting, Backe	62	21	12	69	164	2.31	25.7	10.6	63.7	101.70
11. Junsele	33	3	3	41	80	1.82	25.7	3.7	70.6	101.23
12. Ullånger, Nordingrå	74	12	5	70	161	1.0001	28.7	5.4	65.9	100.01
13. Köpmanholmen	86	20	12	92	210	1.56	26.8	7.9	65.3	101.08
14. Örnsköldsvik, Alfredshem	157	23	14	146	340	1.02	29.4	5.6	65.0	100.61
15. Bredbyn, Mellansel	130	31	8	211	380	1.80	20.2	4.8	75.0	99.45
16. Björna, Gideå	76	30	5	102	213	1.53	21.4	8.6	70.0	99.04
Total	2.831	647	279	2.715	6.472	0.71	27.9	7.4	64.7	100.13

Map 10 shows gene frequencies for the different populations. Below the frequencies of genes A, B, and 0, the frequency of Rh-negative individuals is given (see Map 10).

The frequency of A+AB shows a significant heterogeneity ($\chi^2=59.95$, 15 d.f., $0.001>P$). As in the conscript material, there are low A-frequencies in Ångermanland and an increase in Medelpad. The agreement between the two series of data is striking. Access to these blood donor records makes possible a valuable confirmation of the existence of the low A-frequencies and high 0-frequencies.

The frequency of B+AB shows a significant heterogeneity ($\chi^2=32.16$, 15 d.f., $0.01>P>0.001$). The geographical variation of the B-gene frequency also shows in general the same picture as the conscript material. Thus, frequencies are highest in the Medelpad coastal area. This material, furthermore, shows low frequencies for northern Ångermanland. Sample 10 in this material, however, deviates slightly by a B-frequency which is higher than in the conscript material from the corresponding region.

The frequency of the 0-group shows a significant heterogeneity ($\chi^2=66.29$, 15 d.f., $0.001>P$). In this material, also, the 0-frequency is remarkably high, four samples having a gene frequency of 70 per cent and more. Here there is important confirmation of the high 0-frequency in the conscript material, and thus there is good reason for assuming our AB0-results to be correct.

The Rh-system

The frequency of D-negative individuals shows a significant heterogeneity ($\chi^2=32.50$, 15 d.f., $0.01>P>0.001$). Map 10 shows the frequencies of the different samples. Summarizing it can be said that the frequencies are at a maximum around the lower course of the Ångerman river and in the coastal region immediately north. The frequency also rises somewhat in western Medelpad, probably in connection, as we shall see later, with the occurrence of higher frequencies in Jämtland. In all the northern and northwestern part of Ångermanland the frequencies are, however, low. Since it is known that the Lapps have low frequencies, the question may be raised as to whether Lappish influence can exist as far south as Ångermanland. We have seen, however, that the AB0-distribution does not indicate a Lappish element. The Finns have relatively low frequencies of D-negative individuals, and an additional eastern influence may also be responsible for the observed drop of the frequencies.

iii. *The paternity material*

From this area data have been obtained for 398 individuals (328 for the Rh-system), distributed over 5 regions.

The A_1A_2B0-system

From among the original classifications, subregions 1—3, corresponding to the province of Ångermanland, and subregions 4—5, corresponding to the province of Medelpad, have been combined.

TABLE 23. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*

(Blood donor material)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	184	81.4	42	18.6	226	56.9	43.1
2	275	84.4	51	15.6	326	60.5	39.5
3	353	86.5	55	13.5	408	63.3	36.7
4	1.997	85.3	343	14.7	2.340	61.7	38.3
5	381	85.2	66	14.8	447	61.5	38.5
6	194	80.2	48	19.8	242	55.5	44.5
7	116	82.9	24	17.1	140	58.6	41.4
8	563	89.5	66	10.5	629	67.6	32.4
9	145	87.3	21	12.7	166	64.4	35.6
10	144	87.8	20	12.2	164	65.1	34.9
11	70	87.5	10	12.5	80	64.6	35.4
12	134	83.2	27	16.8	161	59.0	41.0
13	175	83.3	35	16.7	210	59.1	40.9
14	306	90.0	34	10.0	340	68.4	31.6
15	340	89.5	40	10.5	380	67.6	32.4
16	176	82.6	37	17.4	213	58.3	41.7
Total	5.553	85.80	919	14.20	6.472	62.32	37.68

The frequencies of the total A-gene are uniform and relatively low. The frequencies of A+AB show no heterogeneity ($\chi^2=5.02$, 4 d.f., $0.3>P>0.2$). Also regarding A_2+A_2B no heterogeneity exists ($\chi^2=2.37$, 4 d.f., $0.7>P>0.5$). For the county the frequency of the gene A_2 is about 9 per cent. B+AB is homogeneous ($\chi^2=5.06$, 4 d.f., $0.3>P>0.2$), with B-frequencies lying around 7 per cent. In subregion 3 (n=125) the frequency of gene 0 is 68.1 per cent. This agrees with the two earlier sets of material. There is no significant heterogeneity for 0.

The Rh-system

Table 25 shows the total frequencies of the CDE- and DE-groups to be lower here than in the two preceding areas. The frequency of Rh-negative individuals seems to be lower in the northern part of the area, thus agreeing with the

TABLE 24. *A_1A_2B0 groups and gene frequencies.*

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+p+r
1—3	65	24	18	6	3	86	202	0.28	19.4	8.8	6.9	64.9	100.45
4—5	65	26	21	5	2	77	196	0.50	19.9	9.5	7.4	63.2	99.35
Total	130	50	39	11	5	163	398	0.004	19.6	9.2	7.2	64.0	99.96

results obtained from the blood donor material. The difference corresponds, however, only to $\chi^2=1.45$, 1 d.f., $0.3>P>0.2$.

TABLE 25. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	Rh-	n
1—3	89	23	19	3	1	1	18	154
%	57.8	14.9	12.3	1.9	0.7	0.7	11.7	100
4—5	85	23	30	5	3	0	28	174
%	48.9	13.2	17.2	2.9	1.7	0	16.1	100
Total	174	46	49	8	4	1	46	328
%	53.05	14.03	14.94	2.44	1.22	0.30	14.02	100

In subregions 4—5 the gene C frequencies seem to be lower than in the more northern regions. The heterogeneity test gave $\chi^2=4.57$, 1 d.f., $0.05>P>>0.02$.

The variation of gene E is inconsiderable.

TABLE 26. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1—3	63.8	36.2	48.4	51.6	15.1	84.9	154
4—5	57.9	42.1	39.8	60.2	16.6	83.4	174
Total	60.56	39.44	43.70	56.30	15.90	84.10	328

The MN-system

The consistency of the material is satisfactory.

The frequencies for the genes M and N are the same in either part region, and the M-frequency lies above 60 per cent, as in the two northernmost counties.

TABLE 27. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1—3	73	100	29	202	0.31	60.9	39.1
4—5	71	97	28	196	0.31	60.9	39.1
Total	144	197	57	398	0.51	60.93	39.07

The P-system

For the area as a whole the frequency of gene P is somewhat higher than in the preceding areas. In subregions 1—3 the frequency of P seems to be relatively low, apparently joining the Lappish areas in the north. The differ-

ence between subregions 1—3 and subregions 4—5 is, however, not significant ($\chi^2=1.39$, 1 d.f., $0.3>P>0.2$).

TABLE 28. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1—3	153	75.7	49	24.3	202	50.7	49.3
4—5	158	80.6	38	19.4	196	56.1	43.9
Total	311	78.14	87	21.86	398	53.25	46.75

iv. *Summary*

The frequencies of A are highest in the south. Frequencies of A which, for Scandinavia, are very low, are found in the major part of Ångermanland. The frequencies of B are highest farthest in the southeast and lowest in the north. 0-frequencies are very high in the northern part, and merge with those in the southern part of Västerbotten county. The frequency of D-negative individuals is highest in the coastal area and in the southwest, and lowest in the northern and northwestern parts of the area. The C-frequency seems lowest in the southern part. The frequency of M is homogeneous, and lies above 60 per cent. The P-frequencies show no significant variation.

4. Main region IV. The county of Jämtland

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

The previously mentioned investigations by HULTKRANTZ (1897) gave the results as shown in Table 29.

TABLE 29.

	Number	Stature cms	Cephalic index	Colour of eyes %				Colour of hair %			
				blue	grey	mixed	brown	light	brown	red	black
Natives	347	172.6	77.4	40.9	31.1	22.2	5.8	18.8	67.4	1.4	12.4
Immigrants	141	172.4	77.2	46.4	23.2	24.8	5.6	25.6	61.6	—	12.8

HULTKRANTZ characterized the population of Jämtland as tall, asserting that the area was colonized from Tröndelag — which has the tallest population in Norway — and that it still receives contributions from this source. He made a regional study of the material; it is, however, too scanty for such a purpose. His published results cannot be checked, and must, on account of the small number of individuals examined, be accepted with great reserve.

FLODSTRÖM's study in 1926 dealt with 628 persons distributed over assize divisions. Considering the large area of Jämtland, this number is small.

For the Lapps there are data of DAHLBERG and WAHLUND (1941) (see Table 2). According to the maps of LUNDMAN, the southeastern part of the

area is characterized by taller stature and lower cephalic index. In the southern part (Härjedalen) the color of the eyes is allegedly darker.

By way of a control of earlier mappings, I have undertaken a review of the primary material from *"The Racial Characters ..."*. Data from 950 conscripts were studied. Except for stature, the regional classification was the same as that used in connection with the blood donor material. Space limitations preclude the presentation of all tabular data (cf. BECKMAN, 1956). The cephalic index showed uniform values, and no certain variation could be established. According to FLODSTRÖM's material, stature should be taller in the southern part of the county (Härjedalen) than in central Jämtland; but according to *"The Racial Characters ..."* a lower stature is, on the contrary, found in the southern part. In both versions the tallest stature is reported for eastern Jämtland. No certain variation could be established for the frequency of dark-eyed individuals. Because of the small amount of material underlying the mapping the details of the earlier anthropological maps of Jämtland do not appear very reliable.

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

The material comes from the infantry regiment at Östersund (I: 5).

Regional classification

Subregion	Parishes
1	Frostviken, Alanäs
2	Hotagen, Rönnöfors, Laxsjö, Föllinge
3	Offerdal, Alsen, Mörsil, Mattmar, Kall
4	Ström, Gåxsjö, Hammerdal
5	Aspås, Lit, Näskott, Ås, Rödön, Häggenås, Kyrkås
6	Stugun, Fors, Ragunda, Borgvattnet, Håsjö
7	Frösö, Sunne, Norderö, Marieby, Brunflo, Lockne, Näs
8	Hallen, Oviken, Marby, Myssjö
9	Hällesjö, Nyhem, Revsund, Sundsjö, Bräcke
10	Åre, Undersåker
11	Storsjö, Tännäs, Lillhärdal, Linsell
12	Hackås, Bodsjö, Åsarna, Rätan, Klövsjö, Berg
13	Ytterhogdal, Ängersjö, Älvros, Överhogdal, Sveg, Hede, Vemdalen.

The regions correspond fairly well to natural geographical divisions.

The χ^2-test shows a good consistency except for subregion 7. A test for the heterogeneity of A+AB gives the following result: $\chi^2=15.01$, 12 d.f., $0.3>P>>0.2$. Thus, gene A shows a rather small variation. The lowest frequency, 27.3 per cent, is found in subregion 3, while frequencies above 35 per cent are encountered in the north and the southeast (see Map 11).

The frequency of B+AB shows a significant heterogeneity ($\chi^2=49.60$, 12 d.f., $0.001>P$). Subregion 1 shows the minimum value — 2.6 per cent — very low for Swedish conditions, even in comparison with examinations of purebred

TABLE 30. *AB0 groups and gene frequencies.*
(Conscript material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	153	11	2	100	266	1.92	35.6	2.6	61.8	99.27
2	98	22	7	56	183	2.19	35.0	8.3	56.7	98.29
3	155	43	24	156	378	1.88	27.3	9.2	63.5	100.96
4	202	46	20	170	438	0.01	29.8	7.9	62.3	99.94
5	151	39	12	114	316	2.06	30.7	8.4	60.9	98.85
6	164	19	13	139	335	1.16	31.4	4.9	63.7	100.64
7	145	35	27	124	331	4.17	30.4	9.7	59.9	101.72
8	100	28	13	90	231	0.10	28.6	9.3	62.1	100.30
9	113	17	5	65	200	2.19	36.2	5.7	58.1	98.63
10	96	12	6	91	205	0.09	29.0	4.5	66.5	100.21
11	120	20	7	109	256	0.22	29.0	5.4	65.6	99.68
12	204	32	16	160	412	0.01	31.7	6.0	62.3	100.06
13	200	43	15	156	414	1.12	30.8	7.3	61.9	99.31
Total	1.901	367	167	1.530	3.965	0.151	30.8	7.0	62.2	99.92

Lapps. The data for the parish of Frostviken, taken by itself, show a still lower frequency for B and a still higher one for A (see Table 31).

TABLE 31. *AB0 groups and gene frequencies in Frostviken.*

A	B	AB	0	n	χ^2	p	q	r	p+q+r
99	5	0	51	155	0.11	40.2	1.6	58.2	99.80

The value for B, 1.6 per cent, is the lowest which has been encountered in Sweden. As an important Lappish element is known to exist in Frostviken, it might be justifiable to connect the low B-frequency with this. The high A-frequency points in the same direction.

The highest B-frequency is found in subregion 7, at Storsjön, but subregions 3 and 8 also exhibit values above 9 per cent. Lower values, about and below 5 per cent, occur partly in eastern Jämtland, partly in the mountainous areas to the north and southwest. It is noteworthy that in subregion 3 the frequency is high, interrupting lower frequencies generally associated with the mountainous region of the north and the southwest. The situation may be simplified thus: Broadly speaking, the B-frequencies are higher in central Jämtland and in a tract of land that stretches westward through the Scandinavian mountain range.

There is no significant heterogeneity for the 0-group (χ^2=16.83, 12 d.f., 0.2>P>0.1). Frequencies above 65 per cent are found in the west, while the minimum value, 56.7 per cent, occurs in the north. The values otherwise vary around 60 per cent.

Map 11. Frequencies of A, B and 0 genes. (Conscript material.)

ii. *The blood donor material*

The Jämtland blood donor campaign is one of the more extensive, from an organizational point of view. Here the county Red Cross groups have devoted much voluntary work to collect material from most of the local parishes. All blood group determinations were made at the State Laboratory for Forensic Chemistry at Stockholm under the supervision of Professor BROMAN. No absorption test has been made for the AB0-grouping, though this is routinely performed at the laboratory. Tests on blood corpuscles and serum have been carried out. At the start, A_1- and A_2-determinations were made for the first collected material. Later this was discontinued on grounds that it was too time-consuming and relatively unimportant to the immediate needs of the blood donor program. In other aspects, however, the techniques of the campaign have yielded a material of the greatest value to a population-genetical investigation.

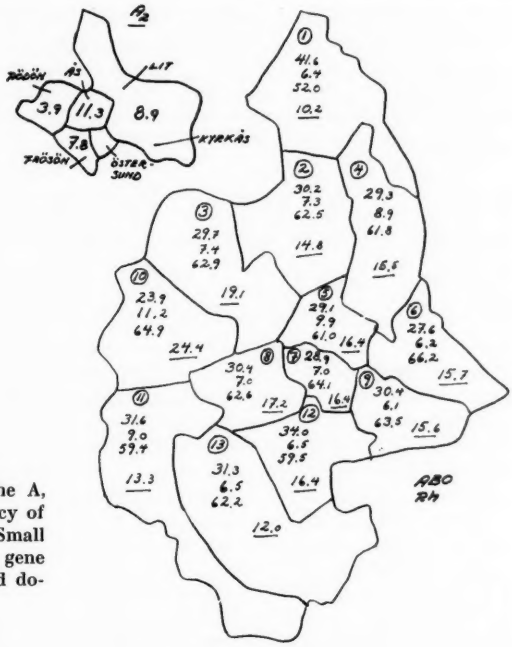
The AB0-system

The consistency of the data is satisfactory.

The frequency of A+AB shows a significant heterogeneity ($\chi^2=39.03$, 12 d.f., $0.001>P$). For the conscript material the variation is not established, perhaps on account of more scanty available material. The geographical variation of

TABLE 32. *AB0 groups and gene frequencies.*
(Blood donor material)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1. Frostviken, Alanäs	128	18	7	53	206	2.56	41.6	6.4	52.0	98.26
2. Hotagen, Laxsjö, Föllinge	168	32	19	145	364	0.86	30.2	7.3	62.5	100.64
3. Offerdal, Alsen, Mörsil, Mattmar, Kall	193	45	13	158	409	2.10	29.7	7.4	62.9	99.07
4. Ström, Gåxsjö, Hammerdal	384	91	45	278	798	0.31	29.3	8.9	61.8	100.28
5. Aspås, Lit, Näskott, Ås, Rödön, Häggenås, Kyrkås	491	150	60	411	1.112	0.36	29.1	9.9	61.0	99.73
6. Stugun, Fors, Ragunda, Borgvattnet, Håsjö	265	54	17	258	594	0.72	27.6	6.2	66.2	99.61
7. Frösö, Sunne. Näs, Norderö, Marieby, Brunflo, Lockne	200	42	17	180	439	0.03	28.9	7.0	64.1	99.89
8. Hallen, Oviken, Marby, Myssjö	146	27	15	121	309	0.02	30.4	7.0	62.6	100.09
9. Hällesjö, Nyhem, Revsund, Sundsjö, Bräcke	222	36	20	191	469	0.57	30.4	6.1	63.5	100.42
10. Åre, Undersåker	66	30	6	70	172	1.61	23.9	11.2	64.9	98.64
11. Storsjö, Tännäs, Lillhärdal	70	16	10	54	150	0.34	31.6	9.0	59.4	100.72
12. Hackås, Bodsjö, Åsarna, Rätan, Klövsjö, Berg	263	41	23	179	506	0.01	34.0	6.5	59.5	100.06
13. Ytterhogdal, Älvros, Sveg, Överhogdal, Hede, Vemdalen, Linsell	223	39	19	177	458	0.01	31.3	6.5	62.2	100.02
14. Östersund	379	78	39	293	789	0.01	31.3	7.7	61.0	100.06
Total	3.198	699	310	2.568	6.775	0.52	30.6	7.8	61.6	99.88



Map 12. Frequencies of the A, B and 0 genes and frequency of Rh-negative individuals. Small map: Frequencies of the A_2 gene in Central Jämtland. (Blood donor material.)

frequencies is shown in Map 12 where it may be noted that subregion 1 has a high A-frequency. This agrees with the conscript material, in which also Frostviken alone had an A-frequency of more than 40 per cent. Here, too, the lowest A-values are found in the west. In the east, however, frequencies decrease slightly, as might have been predicted from the fact that adjoining Ångermanland has very low A-frequencies. Confirmation of high A-frequencies in the vicinity of Frostviken (subregion 1) may be taken as the most important result.

An A_1A_2-grouping has been made, and the results are accounted for in Table 33 and in Map 12 (small map).

A_1A_2 has been determined in only a few of the parishes around and east of Östersund. The consistency of the total material is not satisfactory. One of the constituent areas exhibits an inconsistency. Some notion may nevertheless be gained regarding general traits of the variation of the gene A_2. A heterogeneity test for the relative frequency A_2+A_2B gave $\chi^2=13.42$, 3 d.f., $0.01>P>0.001$. Thus, within this relatively small area, a significant variation of A_2+A_2B seems to exist. The variation with regard to gene A_2 can be attributed to the fact that we are considering an area where ancient Lappish and "Nordic" ethnical elements have met. Rödön, considered to be the center of a genuine agricultural population, shows low values of A_2. Here, too, the B-frequency is as high as 11.5 per cent.

TABLE 33. *A_1A_2B0 groups and gene frequencies.*
(Blood donor material)

Subregions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1. Frösön, Östersund	61	22	25	9	0	77	194	0.005	20.0	7.8	9.2	63.0	99.93
2. Ås	82	37	27	6	5	93	250	0.61	19.5	11.3	7.9	61.3	99.32
3. Lit, Kyrkås	52	24	31	4	1	69	181	3.72	17.1	8.9	10.6	63.4	97.93
4. Rödön	69	12	37	6	0	77	201	4.00	21.0	3.9	11.5	63.6	97.93
Total	264	95	120	25	6	316	826	6.01	19.5	8.0	9.6	62.9	98.79

The frequency of B+AB shows a significant heterogeneity ($\chi^2=36.00$, 12 d.f., $0.001>P$) — a similar result and level of significance which were found in the conscript material. Here we find B-frequencies high in the central areas, and decreasing in northern as well as eastern and southeastern Jämtland. As in the conscript material the frequencies are, furthermore, higher toward the west, but among regions no detailed similarity is found in the frequencies. The discrepancy between the two materials is particularly marked in subregion 10, where the blood donor material shows a much higher B-frequency. The same applies to subregion 11. For both subregions combined, a significant difference is seen in the frequency B+AB between the blood donor and conscript material ($\chi^2=14.46$, 1 d.f., $P<0.001$). The circumstance may perhaps be explained by the fact that the conscript material is a sample from the entire area, whereas the blood donor material, showing higher B-frequencies, has been taken from limited areas of greater population density — areas including a greater percentage of people from central Jämtland, where high B-frequencies are typical. Both materials agree, however, on high B-frequencies for the central and western parts of Jämtland, and low frequencies in the northern and southeastern parts.

For the 0-group we find a significant heterogeneity ($\chi^2=31.96$, 12 d.f., $0.01>P>0.001$). High 0-values in the southwestern part of the county coincide with those of the conscript material for subregion 10, but not for subregion 11. In the latter, however, the number of examined individuals is so small that the difference cannot be considered established. Subregion 6, bordering on Ångermanland with its high 0-frequencies, shows more than 66 per cent.

The Rh-system

Percentages of Rh-negative individuals are indicated on Map 12 together with the AB0-distribution (underlined figures).

The heterogeneity-χ^2 is 23.10, 12 d.f., $0.05>P>0.02$.

The frequency of D-negative individuals is high in the central area and in the west, low in the north and the east, and frequencies increase toward the

west. All Härjedalen exhibits low values. We thus recognize a picture analogous to the distribution of gene B. The central and western Jämtland population is characterized by high frequencies of B and D-negative individuals. The lowest frequency of D-negative individuals (10.2 per cent) is found in subregion 1. Since the Rh-negative factor is known to be low among the Lapps, it may be supposed that the Lappish element finds expression here as in the case of gene A.

A high percentage of D-negative individuals is thought to stem from old West-European ethnical elements, and is typically prevalent among the Basques. It may be inquired whether western Jämtland contains an old residual population.

TABLE 34. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*

(Blood donor material)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	185	89.8	21	10.2	206	68.1	31.9
2	310	85.2	54	14.8	364	61.5	38.5
3	331	80.9	78	19.1	409	56.3	43.7
4	674	84.5	124	15.5	798	60.6	39.4
5	930	83.6	182	16.4	1.112	59.5	40.5
6	501	84.3	93	15.7	594	60.4	39.6
7	367	83.6	72	16.4	439	59.5	40.5
8	256	82.8	53	17.2	309	58.5	41.5
9	396	84.4	73	15.6	469	60.5	39.5
10	130	75.6	42	24.4	172	50.6	49.4
11	130	86.7	20	13.3	150	63.5	36.5
12	423	83.6	83	16.4	506	59.5	40.5
13	403	88.0	55	12.0	458	65.4	34.6
14	681	86.3	108	13.7	789	63.0	37.0
Total	5.717	84.38	1.058	15.62	6.775	60.48	39.52

iii. *The paternity material*

From this area come data for 433 individuals (379 for the Rh-system), distributable over 4 part regions (see the map). Of the original regions, the numbers 1 and 4, 5 and 6 have been combined in the tables.

The A_1A_2B0-system

The consistency of the material is satisfactory, and the tables show good agreement of the total data with those obtained from the conscript and the blood donor material.

The frequency of the total A-gene is highest in subregion 1, in agreement with earlier observations. There is no significant variation of the A-gene within the area taken as a whole. The frequency of gene A_2 is higher in the northeast

and the south, as might be expected on the basis of our knowledge of local Lappish influence. A significant difference for A_2+A_2B appears between subregions 1, 4, 5, and 6, and subregions 2 and 3 ($\chi^2=6.77$, 1 d.f., $0.01>P>0.001$).

The variation within the total area of gene B is not significant, but the highest frequencies are found within the same area as in the two previous materials, viz., in the west.

TABLE 35. *A_1A_2B0 groups and gene frequencies.*

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1, 4	37	17	7	0	1	27	89	2.65	23.8	14.8	4.7	56.7	97.85
2	55	29	22	5	4	97	212	0.18	15.3	9.8	7.6	67.3	100.34
3	24	7	10	2	1	22	66	0.61	22.3	8.3	10.5	58.9	98.46
5, 6	19	13	3	3	2	26	66	2.97	18.1	15.1	6.2	60.6	102.72
Total	135	66	42	10	8	172	433	0.02	18.4	11.3	7.2	63.1	99.92

The Rh-system

Here the frequency of the CDE- and DE-groups lies around the Swedish average value. The Rh-negative group exhibited the widest variation. χ^2 for the heterogeneity of Rh- was 5.68, 3 d.f., $0.2>P>0.1$.

In subregion 1 the frequency of Rh-negative individuals is lower, supporting the earlier results from the blood donor material, and points to a Lappish element. In the central and western parts of the area the frequency of Rh-negative individuals is high. Previously a frequency of 24.4 per cent of Rh-negative individuals was observed in subregion 3, and here the frequency is 25.4 per cent (n=59). This confirms, in spite of the small size of the material, the previous result. One CE-individual has been noted.

TABLE 36. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	CE	Rh-	n
1, 4	36	9	9	3	2	0	0	6	65
%	55.4	13.9	13.9	4.6	3.0	0	0	9.2	100
2	87	33	32	4	1	0	1	37	195
%	44.6	16.9	16.4	2.1	0.5	0	0.5	19.0	100
3	28	6	9	1	0	0	0	15	59
%	47.5	10.2	15.2	1.7	0	0	0	25.4	100
6	28	8	10	2	1	0	0	11	60
%	46.7	13.3	16.7	3.3	1.7	0	0	18.3	100
Total	179	56	60	10	4	0	1	69	379
%	47.23	14.78	15.83	2.64	1.06	0	0.26	18.20	100

The variation in frequencies of Rh-negative individuals between subregions 1, 4, and 2, 3 gives $\chi^2=4.40$, 1 d.f., $0.05>P>0.02$.

TABLE 37. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1, 4	65.1	34.9	47.4	52.6	15.0	85.0	65
2	55.3	44.7	38.8	61.2	18.6	81.4	195
3	49.6	50.4	35.0	65.0	13.6	86.4	59
5, 6	55.3	44.7	38.1	61.9	16.3	83.7	60
Total	55.82	44.18	38.62	61.38	16.85	83.15	379

No significant heterogeneity exists for the frequency of C- and E-negative individuals.

Within this area both the C- and the E-gene seem to have lower frequencies than are ascertained further north. The difference for C-negative individuals between Jämtland and the combined counties of Norrbotten and Västerbotten gives $\chi^2=6.22$, 1 d.f., $0.02>P>0.01$. The difference of the gene E between the same areas gives $\chi^2=2.87$, 1 d.f., $0.1>P>0.05$.

The MN-system

The consistency of the material is not satisfactory for subregions 5—6. M-frequencies are higher in subregions 1 and 2, an area directly adjoining the large North-Swedish area with higher M (above 60 per cent). χ^2 for the difference between subregions 1, 2, and 4 and subregions 3, 5, and 6 is 7.78, 1 d.f., $0.01>P>0.001$. Thus, M-frequency is significantly lower in the western part of the county, as might be expected, since a low M-frequency has already been mentioned as a "western criterion". We have already seen that this area of western Jämtland is distinguished by high frequencies of B and Rh-negative individuals. The high frequency of Rh-negative and the low M-frequency both indicate a western influence (immigration via Norway), while the high B-frequency may be a sign of eastern influence. In this connection it may be mentioned that WATKIN (1956) has formulated a hypothesis according to which gene B need not be considered in Western Europe the youngest, from an introgression point of view, but may have been present since early times. One ex-

TABLE 38. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1, 4	32	48	9	89	2.90	63.0	37.0
2	77	100	35	212	2.42	59.9	40.1
3	21	32	13	66	0.17	56.1	43.9
5, 6	19	22	25	66	7.09	45.5	54.5
Total	149	202	82	433	0.84	57.73	42.27

planation would then be found in assuming the population of western Jämtland to constitute a residual population which originally had frequencies that were relatively high for B, low for M, and high for Rh-negative individuals. Another, perhaps more likely explanation would be to assume that the population in question has received immigrations from the west as well as from the east during different periods, thus obtaining its present genetic constitution.

The P-system

The P-positive element is stronger here than it is farther north. The frequency shows homogeneity ($\chi^2=2.11$, 3 d.f., $0.7>P>0.5$).

TABLE 39. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1, 4	75	84.3	14	15.7	89	60.3	39.7
2	171	80.7	41	19.3	212	56.0	44.0
3	50	75.8	16	24.2	66	50.8	49.2
5, 6	51	77.3	15	22.7	66	52.3	47.7
Total	347	80.14	86	19.86	433	55.43	44.57

iv. *Summary*

The frequency of A is highest in the north and lowest in the western and eastern parts. A_2-frequencies decrease toward the west. B-frequencies are highest in the central and western parts and lowest in the north. O-frequencies are highest in the east and the west. The frequency of Rh-negative individuals is highest in the west and lowest in the north and the south. The M-frequency is lowest in the west.

5. Main region V. The county of Gävleborg

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

Our knowledge regarding variations in the anthropometrical characters of this region is founded on FLODSTRÖM's compilation, and local investigations by LUNDMAN (1945). For comparison with his material from Dalecarlia, LUNDMAN has examined 1,375 men and 900 women in inner Hälsingland who tend to be taller than those of Dalecarlia. Furthermore, the cephalic index is higher (by 1.2 units) than in Dalecarlia. Eye and hair coloration is lighter, but the shape of the nose is about the same. Red hair is designated as unusual. According to LUNDMAN, Hälsingland is regionally more uniform than Dalecarlia. He distinguishes three different village groups, i.e., the Vallsta group, the Ljusdal group, and the Alfta group. Of these, the Alfta group is identical with the ethnical stock of the Scandinavian inland. The Vallsta group, on the other hand, is more "Tröndic". The Ljusdal group is less easily identified, but is

probably connected with the Orsa group in Dalecarlia. Elements of Tydal type and Finns are said to be negligible. In LUNDMAN's map for the stature (1946), this is given as shorter in the coastal border of the county of Gävleborg. Analysis of the primary material (FLODSTRÖM's study) shows the difference between the coast and the inland to be insignificant ($0.3>P>0.2$).

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

The material has been collected from the infantry regiments at Östersund and Gävle (1: 5 and I: 14).

The following parishes have been fused into regions:

Subregion	Parishes
1	Hedesunda, Österfärnebo
2	Torsåker, Årsunda, Ovansjö
3	Järbo, Hofors
4	Hamrånge
5	Ockelbo
6	Skog, Hanebo
7	Bollnäs
8	Alfta
9	Ovanåker, Voxna
10	Rengsjö, Trönö, Norrala, Mo, Söderala, Bergvik
11	Arbrå, Undersvik
12	Enånger, Njutånger, Forsa
13	Järvsö
14	Los, Färila
15	Ljusdal, Ramsjö
16	Hassela, Bjuråker, Norrbo, Delsbo
17	Gnarp, Bergsjö, Jättendal, Harmånger, Ilsbo, Hög, Hälsingtuna, Rogsta, Idenor.

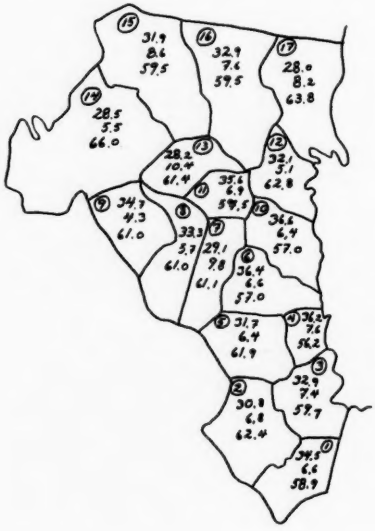
The consistency of the total data is not satisfactory ($\chi^2=4.025$, 1 d.f., $0.05>P>0.02$).

No significant heterogeneity for A+AB exists within the total area ($\chi^2=21.915$, 16 d.f., $0.2>P>0.1$). The average for the region was as high as 32.3 per cent. MOURANT recorded the area as below 30 per cent. Frequencies above 35 per cent are found near the coast in subregions 4, 6, and 10.

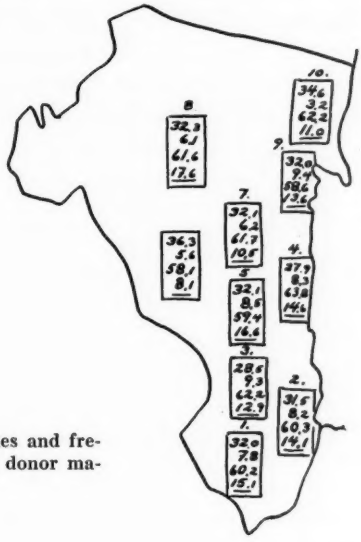
No significant heterogeneity was found for B+AB ($\chi^2=18.24$, 16 d.f., $0.5>P>0.3$). The highest values occurred in subregions 7, 13, and 15. For the frequency B+AB, the difference between subregion 13 and the others gives $\chi^2=4.48$, 1 d.f., $0.05>P>0.02$. Subregions 13 and 15 contain elements of LUNDMAN's Ljusdal group which he considers most closely related to the Orsa group in Dalecarlia. LUNDMAN's view is supported by the fact that both the Orsa and Ljusdal groups have relatively high B-frequencies. The lowest frequencies were found in subregions 8, 9, and 14 in the northwestern part of the area.

TABLE 40. *AB0 groups and gene frequencies.*
(Conscript material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	176	25	19	121	341	1.17	34.5	6.6	58.9	100.80
2	223	43	18	179	463	0.16	30.8	6.8	62.4	99.76
3	229	45	19	159	452	0.58	32.9	7.4	59.7	99.49
4	87	16	7	49	159	0.55	36.2	7.6	56.2	99.10
5	165	29	12	126	332	0.23	31.7	6.4	61.9	99.67
6	194	36	10	118	358	0.55	36.4	6.6	57.0	100.56
7	150	45	19	130	344	0.34	29.1	9.8	61.1	100.47
8	136	20	9	97	262	0.13	33.3	5.7	61.0	99.73
9	161	18	6	107	292	1.13	34.7	4.3	61.0	99.32
10	160	25	10	90	285	1.41	36.6	6.4	57.0	99.01
11	107	18	8	64	197	0.42	35.6	6.9	57.5	99.34
12	105	12	9	85	211	1.01	32.1	5.1	62.8	100.78
13	81	29	7	66	183	2.13	28.2	10.4	61.4	98.37
14	108	16	10	107	241	1.23	28.5	5.5	66.0	100.77
15	117	26	14	87	244	0.04	31.9	8.6	59.5	100.20
16	159	31	16	113	319	0.001	32.9	7.6	59.5	99.98
17	148	42	10	130	330	2.88	28.0	8.2	63.8	98.77
Total	2.506	476	203	1.828	5.013	**4.025**	32.3	7.0	60.7	99.62



Map 13. Frequencies of the A, B and 0 genes. (Conscript material.)



Map 14. Frequencies of the A, B and 0 genes and frequencies of Rh-negative individuals. (Blood donor material.)

There was no significant heterogeneity for the 0-gene. The values varied between 57 per cent in subregions 6 and 10 and 66 per cent in subregion 14. The average for the entire area was 60.7 per cent. This agrees with MOURANT's map (see Map 13).

ii. *The blood donor material*

From the blood donor campaign in the county of Gävleborg data on 6,556 individuals has been obtained. The material has not been registered by parishes.

The AB0-system

The composition of the total material and of all constituent areas is satisfactory.

The frequency of A+AB shows no significant heterogeneity ($\chi^2=16.83$, 9 d.f., $P \approx 0.05$).

Heterogeneity-χ^2 for B+AB is 18.53, 9 d.f., $0.05>P>0.02$. The geographical variation is shown in Map 14. Compared with the rest of the area, the B+AB-frequency is higher in the coastal samples — subregions 2, 3, 4, 5, and 9 ($\chi^2=8.54$, 1 d.f., $0.01>P>0.001$). Low frequencies in the northwest were found also in the conscript material.

No significant heterogeneity exists for the 0-group ($\chi^2=8.03$, 9 d.f., $0.7>P>>0.5$).

In this material the frequency variation is smaller than in the conscript material. (See Map 14.)

TABLE 41. *AB0 groups and gene frequencies.*

(Blood donor material)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1. Gysinge, Hedesunda, Österfärnebo, Hofors, Storvik, Sandviken, Torsåker, Ovansjö	814	161	92	618	1.685	1.42	32.0	7.8	60.2	100.41
2. Gävle, Valbo	1.258	274	145	967	2.644	0.87	31.5	8.2	60.3	100.26
3. Hamrånge, Lingbo, Norrsundet, Ockelbo	64	18	8	57	147	0.006	28.5	9.3	62.2	100.09
4. Ljusne, Söderala, Marma, Söderhamn	142	34	20	140	336	1.73	27.9	8.3	63.8	100.95
5. Bergvik, Bollnäs, Kilafors, Norrala, Trönö	146	32	17	107	302	0.03	32.1	8.5	59.4	100.14
6. Alfta, Ovanåker	136	16	11	84	247	0.11	36.3	5.6	58.1	100.28
7. Arbrå, Undersvik	83	15	4	60	162	1.30	32.1	6.2	61.7	98.88
8. Färila, Ljusdal, Dellen	156	24	13	119	312	0.07	32.3	6.1	61.6	100.19
9. Forsa, Hudiksvall	277	63	44	210	594	3.11	32.0	9.4	58.6	101.13
10. Bergsjö, Hassela, Gnarp, Harmånger	69	4	4	50	127	0.77	34.6	3.2	62.2	100.73
Total	3.145	641	358	2.412	6.556	3.16	31.7	7.9	60.4	100.31

The Rh-system

The frequencies of D-positive and D-negative individuals as well as those of the genes D and d are shown in Table 42. Map 14 shows the frequency of D-negative individuals. There is no significant heterogeneity ($\chi^2=19.02$, 9 d.f., $0.05>P>0.02$). Subregions 6 and 7 show remarkably low frequencies. Between subregion 6 and the others, we discern a significant difference in the D-negative-frequency ($\chi^2=7.92$, 1 d.f., $0.01>P>0.001$). The high frequency in the northwest is perhaps associated with the high frequencies in Jämtland.

TABLE 42. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*

(Blood donor material)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	1.431	84.9	254	15.1	1.685	61.1	38.9
2	2.272	85.9	372	14.1	2.644	62.5	37.5
3	128	87.1	19	12.9	147	64.1	35.9
4	287	85.4	49	14.6	336	61.8	38.2
5	252	83.4	50	16.6	302	59.3	40.7
6	227	91.9	20	8.1	247	71.5	28.5
7	145	89.5	17	10.5	162	67.6	32.4
8	257	82.4	55	17.6	312	58.0	42.0
9	513	86.4	81	13.6	594	63.1	36.9
10	113	89.0	14	11.0	127	66.8	33.2
Total	5.625	85.80	931	14.20	6.556	62.32	37.68

iii. *The paternity material*

From this area data have been obtained on 488 individuals (399 for the Rh-system). This material has been divided into two part regions, corresponding to the provinces of Hälsingland and Gästrikland.

The A_1A_2B0-system

The composition of the material is satisfactory. The gene frequencies for the total sample agree well with the two other materials. The variations between subregions are slight and not significant for all genes. For the entire area the frequency of A_2 reaches a height of about 10 per cent. Possibly this is due to a slight Lappish intermixture, especially in the southwestern part of the county. Also, the low frequencies of D-negative individuals and the relatively low B-frequencies may indicate a Lappish influence.

Also in this material the B-frequency of the southern coastal area (subregion 5) is higher than that of the inland (subregion 4). However, the difference is not significant.

TABLE 43. *A_1A_2B0 groups and gene frequencies.*

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1—3	98	23	19	4	6	90	240	0.02	24.2	8.4	6.2	61.2	100.11
4—5	100	34	20	6	4	84	248	0.13	24.3	10.9	6.3	58.5	99.66
Total	198	57	39	10	10	174	488	0.03	24.3	9.7	6.3	59.7	99.89

The Rh-system

Compared with Jämtland, the frequency of D-negative individuals is low here, resembling the figures for the more northern counties. The difference between Jämtland and this area gives $\chi^2=6.46$, 1 d.f., $0.02>P>0.01$. The agreement with the blood donor material is good. There is a significant heterogeneity for the DE-frequency ($\chi^2=6.71$, 1 d.f., $0.01>P>0.001$).

Within this area no significant heterogeneities exist for the frequencies of C-, D-, and E-negative individuals.

TABLE 44. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	Rh-	n
1—3	95	30	29	7	5	0	24	190
%	50.0	15.8	15.3	3.7	2.6	0	12.6	100
4—5	99	27	54	4	1	1	23	209
%	47.4	12.9	25.8	1.9	0.5	0.5	11.0	100
Total	194	57	83	11	6	1	47	399
%	48.62	14.29	20.80	2.76	1.50	0.25	11.78	100

TABLE 45. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1—3	61.0	39.0	43.8	56.2	17.0	83.0	190
4—5	65.4	34.6	37.4	62.6	22.0	78.0	209
Total	63.22	36.78	40.34	59.66	19.59	80.41	399

The MN-system

The consistency of the material is satisfactory. As in Jämtland, the M-frequency was lower than in the three more northern areas. The variation between the part regions is not significant.

TABLE 46. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1—3	79	108	53	240	1.91	55.4	44.6
4—5	75	132	41	248	1.79	56.9	43.1
Total	154	240	94	488	0.0008	56.10	43.90

The P-system

In comparison with those of the northernmost main regions, the frequencies of gene P are higher and resemble more those of Jämtland and the southern

part of Västernorrland county. No significant difference is found between the two part regions.

TABLE 47. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1—3	193	80.4	47	19.6	240	55.7	44.3
4—5	207	83.5	41	16.5	248	59.4	40.6
Total	400	81.97	88	18.03	488	57.54	42.46

iv. *Summary*

The A-frequencies are uniform and relatively high. The A_2-frequency is highest (above 10 per cent) in the southern part. The B-frequencies are somewhat higher in the coastal area. The frequency of D-negative individuals is lowest in the west, and highest in the northwest. Within the region the genes C, E, M, and P exhibit no significant heterogeneities.

6. Main region VI. Dalecarlia

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

Dalecarlia is the only Swedish province which has been the subject of a special anthropological investigation. LUNDMAN (1945) includes a detailed regional analysis. The anthropometrical characters of the population prior to the industrial revolution were studied by the selection of subjects whose parents were both born locally. The smallest units of analysis were village data which may be combined into larger units of greater applicability. In Dalecarlia LUNDMAN examined about 11,000 individuals (men and women of different ages). The stature of males in Dalecarlia corresponds roughly with the average stature in northern Europe. In a tract stretching obliquely across Dalecarlia in a NW—SE direction, the stature is shorter. The cephalic index is about 76, the face rather broad, and the face length slightly below the mean for Sweden. The different characters vary rather considerably in Dalecarlia. According to LUNDMAN, the village means for the stature vary from 165 to 180 cms., and the face index from 83 to 95. To sum up, LUNDMAN distinguishes within Dalecarlia, elements of four regionally separated groups (ethnic stocks), each of them being characterized by a main type. In the northeast a tall, fair type, often with a convex shape of the nasal bridge profile (Trönde type), is claimed to be characteristic. In the central parts of the province a shorter, dolichocephalic, fair type prevails, with broad face and preponderantly concave nasal bridge shape. This, the Västmanland type, is the next oldest in the colonization history of the province. LUNDMAN (1946) believed that the ancestors of the Västmanland types entered Sweden from the south, via Denmark, soon after the melting of the inland ice. The oldest element is represented, according to LUNDMAN, by the Tydal type occurring mainly in northern Dalecarlia and most

notably in the parish of Älvdalen. Faces are very broad; the shape of the nasal bridge profile is concave, and the pigmentation dark. The Göta type, prevalent in southwestern Dalecarlia, is characterized by relatively tall stature, narrow skulls, very narrow faces, and light pigmentation. Foreign elements infiltrated during the seventeenth and eighteenth centuries. According to LUNDMAN, a gipsy admixture is noticeable in certain regions. He states, too, that the Finnish population which immigrated during the seventeenth century has been practically assimilated by the aboriginal population, leaving no visible anthropological trace.

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

The material has been obtained from the infantry regiment at Falun (I: 13).

Regional classification

Subregion	Parishes
1	Idre and Särna
2	Transtrand and Lima
3	Älvdalen
4	Mora, Våmhus, and Sollerön
5	Malung and Venjan
6	Orsa
7	Ore
8	Rättvik and Boda
9	Siljansnäs and Leksand (without Djura)
10	Järna and Äppelbo
11	Nås, Floda, Säfsnäs, and Mockfjärd
12	Grangärde and Ludvika rural community
13	Norrbärke
14	Söderbärke and Malingsbo
15	Ål and Bjursås
16	Djura (a part of Leksand) and Gagnef
17	Stora Tuna
18	Falu rural community, Aspeboda, Vika, and Torsång
19	Sundborn, Svärdsjö, and Enviken
20	Stora Skedvi and Säter rural community
21	Husby
22	Hedemora rural community, Folkärna, By, Garpenberg, and Grytnäs
23	Gustavs and Silvberg.

Densely populated eastern Dalecarlia has been divided into fairly small areas. Those in the northwest are larger because of larger parishes, and the data for certain parishes have been considered together.

The consistency with the expected frequencies is satisfactory for the total material, but two of the constituent areas show inconsistencies.

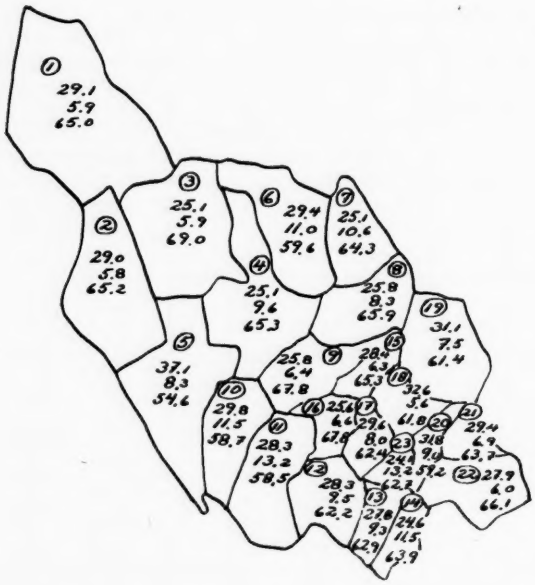
TABLE 48. *AB0 groups and gene frequencies.*
(Conscript material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	108	21	9	98	236	1.06	29.1	5.9	65.0	99.24
2	119	28	2	104	253	3.40	29.0	5.8	65.2	98.70
3	166	42	12	191	411	**4.65**	25.1	5.9	69.0	98.91
4	283	96	35	312	726	0.13	25.1	9.6	65.3	100.18
5	257	50	23	135	465	1.64	37.1	8.3	54.6	99.03
6	169	60	18	129	376	2.39	29.4	11.0	59.6	98.72
7	63	24	9	68	164	0.01	25.1	10.6	64.3	100.12
8	147	44	12	152	355	0.87	25.8	8.3	65.9	99.38
9	187	43	12	201	443	0.72	25.8	6.4	67.8	99.56
10	162	51	31	135	379	1.88	29.8	11.5	58.7	101.17
11	137	58	22	111	328	0.27	28.3	13.2	58.5	99.50
12	88	26	11	79	204	0.002	28.3	9.5	62.2	100.04
13	145	41	20	138	344	0.37	27.8	9.3	62.9	100.46
14	57	25	7	60	149	0.27	24.6	11.5	63.9	99.38
15	110	19	11	107	247	0.60	28.4	6.3	65.3	100.57
16	101	24	7	110	242	0.26	25.6	6.6	67.8	99.64
17	458	107	44	388	997	0.04	29.6	8.0	62.4	99.92
18	126	14	14	101	255	3.54	32.6	5.6	61.8	101.41
19	183	38	15	142	378	0.15	31.1	7.5	61.4	99.73
20	146	35	7	117	305	0.003	31.8	9.0	59.2	100.05
21	97	21	9	94	221	**4.95**	29.4	6.9	63.7	101.86
22	138	24	12	138	312	0.54	27.9	6.0	66.1	100.46
23	56	27	13	66	162	1.17	24.1	13.2	62.7	101.32
Total	3.503	918	355	3.176	7.952	1.78	28.3	8.3	63.4	99.80

A significant heterogeneity exists for A+AB (χ^2=62.58, 22 d.f., P<0.001). The average, 28.3 per cent, agrees with MOURANT's earlier map. Frequencies vary from 24.1 per cent in subregion 23 to 37.1 per cent in subregion 5. Apart from this aforementioned maximum in subregion 5 (in the southwestern part of the province), frequencies above 30 per cent are found only in the east in subregions 18, 19, and 20. The eastern region is similar to the southern part of Gävleborg county.

The B+AB frequency also shows a significant heterogeneity (χ^2=87.66, 22 d.f., P<0.001), with a relatively high average (8.3 per cent). Six regions show frequencies above 10 per cent. The highest frequency, 13.2 per cent, in subregion 11, corresponds to the values found in Finland. Low values, down to 5—6 per cent, were found both in the northwest and the east. Map 15 shows a northsouth stretch of high B-values dividing Dalecarlia into two areas of lower B-frequencies.

Dalecarlia's high B-frequencies should be considered indicative of the presence of eastern elements. It is possible that the high frequencies have ac-



Map 15. Frequencies of the A, B and 0 genes. (Conscript material.)

cumulated in areas where the Finnish immigration during the seventeenth century is known to have been considerable. According to HÜLPHERS (1763), the number of Finnish households during the eighteenth century rarely exceeded 10 per cent in the parishes of Dalecarlia. Thus, the causes for this frequency increase may be antecedent to the Finnish immigration in the seventeenth century, though the latter factor cannot be disregarded. (Map 15.)

Significant heterogeneity exists for the frequency of the 0-group ($\chi^2=291.02$, 22 d.f., $P<0.001$). Subregion 3 shows a maximum value of 69 per cent. This sample shows, however, a significant inconsistency with expected values, which may have somewhat increased the 0-frequency. Values above 65 per cent occur in the regions around Lake Siljan and the river Österdalälven, and in a smaller area in the southeast. Southwestern Dalecarlia, a separate region in which the low values are concentrated, is pointed out by LUNDMAN as a region inhabited mainly by "Göta types". This does not agree with the concept that the southwest Swedish Göta type should have rather high 0-frequencies.

ii. *The blood donor material*

By the courtesy of Dr. ERIK H. MÅRTENSSON, Falun, I have obtained data from the blood donor campaign in this area. Blood group determinations on 10,719 individuals were made at the Falu Hospital. The observed and expected frequencies showed a significant inconsistency ($\chi^2=13.74$, 1 d.f., $0.001>P$), cf. Table 49.

TABLE 49.

	A	B	AB	0	n	χ^2	p+q+r
Observed	4.791	1.172	627	4.129	10.719	13.74	100.51
Expected	4.848.1	1.245.1	558.4	4.067.4	10.719		

We notice a considerable excess of AB- and 0-individuals, and a corresponding deficiency of A- and B-individuals. This type of inconsistency, implying an excess of AB, is relatively unusual. The most common deviation is a deficiency of AB-individuals. The excess of 0 is compensated by deficiencies of both B and A. Consequently, the calculation of genes A and B is influenced only in a relatively small degree. The frequency for gene 0 becomes, however, evidently too high. Two of the part series (Grytnäs and the town of Avesta, and Gustavs) had abnormally high AB-frequencies. They were excluded from the total material before the further examination. The remaining material included data for 9,966 individuals.

This material was classified into 21 part regions, corresponding to the classification for the conscript material.

The AB0-system

In spite of the exclusion of inconsistent samples, a significant deviation from the expected frequencies still remains (for the total material $\chi^2=7.88$, 1 d.f., $0.01>P>0.001$). Only one of the constituent areas, subregion 12 shows a significant inconsistency. If this region is omitted, we obtain $\chi^2=3.21$, 1 d.f., $0.1>P>0.05$ for the rest of the material.

The difference for the frequency A+AB between this material and the conscript material gives $\chi^2=6.87$, 1 d.f., $0.01>P>0.001$. Thus, the A-frequency is higher in this material. The difference for the frequency B+AB between the two series of data is $\chi^2=1.99$, 1 d.f., $0.2>P>0.1$.

The variation of the frequencies A+AB between the different part regions yields $\chi^2=33.43$, 20 d.f., $0.05>P>0.02$. The variation of the frequencies B+AB gives $\chi^2=215.43$, 20 d.f., $0.001>P$. In the conscript material the levels of significance are $0.01>P>0.001$ and $0.001>P$, respectively. Thus, in either case, the gene B displays greater heterogeneity.

A comparison between Map 16 and Map 15 shows in the main agreement. The B-frequencies are fairly high in central Dalecarlia, but decrease toward the east. B-frequencies higher than 10 per cent are found throughout large parts of Dalecarlia. In the conscript material the subregions 1—3 show low and uniform frequencies (5.8—5.9 per cent), while in the blood donor material their frequencies are high and of similar magnitude (9.8—10.2 per cent). The difference is significant. The reason may be that the conscript material, which has been arranged according to the parishes of birth, is a more representative sample. Certainly the blood donor material comes mostly from those easily accessible, densely populated places whose populations may be infused with the high B-frequency element of central Dalecarlia. Individuals from out-of-

TABLE 50. *AB0 groups and gene frequencies.*
(Blood donor material)

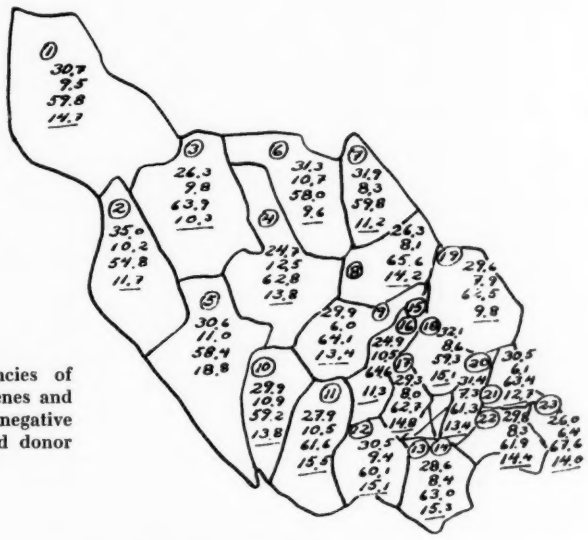
Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1. Idre, Särna	58	17	5	42	122	0.61	30.7	9.5	59.8	98.60
2. Transtrand, Lima	37	7	8	25	77	1.60	35.0	10.2	54.8	102.79
3. Älvdalen	107	33	18	114	272	1.67	26.3	9.8	63.9	101.09
4. Mora, Våmhus, Sollerön	112	53	16	115	296	0.41	24.7	12.5	62.8	99.43
5. Malung, Venjan	115	36	17	87	255	0.001	30.6	11.0	58.4	99.96
6. Orsa	260	74	42	195	571	0.61	31.3	10.7	58.0	100.54
7. Ore	80	16	11	62	169	0.73	31.9	8.3	59.8	100.96
8. Rättvik, Boda	81	19	13	91	204	2.84	26.3	8.1	65.6	101.48
9. Siljansnäs, Leksand, Djura	52	8	5	47	112	0.43	29.9	6.0	64.1	100.72
10. Järna, Äppelbo	148	47	22	117	334	0.002	29.9	10.9	59.2	100.04
11. Nås, Floda	84	28	12	76	200	0.007	27.9	10.5	61.6	100.09
12. Grangärde, Grängesberg, Ludvika	535	127	89	449	1.200	9.33	30.5	9.4	60.1	101.33
13. 14. Norrbärke, Smedjebacken, Söderbärke, Malingsbo	218	54	29	201	502	0.32	28.6	8.4	63.0	100.34
15. 16. Gagnef, Mockfjärd, Ål, Bjursås	136	52	18	147	353	0.009	24.9	10.5	64.6	99.93
17. St. Tuna	888	204	98	780	1.970	0.74	29.3	8.0	62.7	100.26
18. St. Kopparberg, Falun, Vika	511	114	61	374	1.060	0.08	32.1	8.6	59.3	100.13
19. Sundborn, Svärdsjö, Enviken	119	28	14	103	264	0.02	29.6	7.9	62.5	99.88
20. St. Skedvi, Säter	227	44	22	177	470	0.03	31.4	7.3	61.3	100.10
21. Husby	144	25	10	119	298	0.12	30.5	6.1	63.4	99.76
22. Hedemora Folkärna, Krylbo köp.	399	96	44	334	873	0.004	29.8	8.3	61.9	100.03
23. By	150	29	16	169	364	1.75	26.0	6.4	67.6	100.77
Total	4.461	1.111	570	3.824	9.966	7.88	29.6	8.8	61.6	100.40

the-way regions have probably been included to a comparatively small extent in the blood donor data.

In both materials the highest A-frequencies were found in the west, and similarly subregions 3, 4, 8, 15, and 16 showed low A-frequencies.

The heterogeneity test for the frequencies of the 0-group gives $\chi^2=35.58$, 20 d.f., $0.02>P>0.01$. Because of the discrepancies of the 0-group, nothing definite can be said about the significance of the variation.

The 0-values are higher in the conscript material than in this one. In both sets of data subregions 3, 4, 5, 9, 15, and 16 showed relatively high 0-frequencies (see Map 16).



Map 16. Frequencies of the A, B and 0 genes and frequency of Rh-negative individuals. (Blood donor material.)

The Rh-system

The frequencies of the different part regions can be seen in Table 51.

The total material exhibits a relatively low frequency, i.e., 13.97 per cent, of D-negative individuals. No significant heterogeneity exists for the frequency of D-negative individuals ($\chi^2=28.77$, 20 d.f., $0.1>P>0.05$). In Map 16 the frequency of D-negative individuals is found below the AB0-figures (underlined figures). The maximum, 18.8 per cent, is found in subregion 5; the minimum, 9.6 per cent, in subregion 6. The difference between subregion 5 and the remaining subregions corresponds to $\chi^2=4.76$, 1 d.f., $0.05>P>0.02$. The higher figures for southern Dalecarlia as a whole are not significant. The low frequencies in northern and eastern Dalecarlia connect with similar frequencies in Gävleborg county. The relatively low frequencies for D-negative individuals may depend upon eastern elements, since eastern populations show relatively low frequencies of D-negative individuals.

TABLE 51. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*

(Blood donor material)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	104	85.3	18	14.7	122	61.6	38.4
2	68	88.3	9	11.7	77	65.9	34.1
3	244	89.7	28	10.3	272	67.9	32.1
4	255	86.2	41	13.8	296	62.8	37.2
5	207	81.2	48	18.8	255	56.6	43.4
6	516	90.4	55	9.6	571	69.0	31.0
7	150	88.8	19	11.2	169	66.5	33.5
8	175	85.8	29	14.2	204	62.3	37.7
9	97	86.6	15	13.4	112	63.4	36.6
10	288	86.2	46	13.8	334	62.9	37.1
11	169	84.5	31	15.5	200	60.6	39.4
12	1.019	84.9	181	15.1	1.200	61.2	38.8
13 } 14	425	84.7	77	15.3	502	60.8	39.2
15 } 16	313	88.7	40	11.3	353	66.3	33.7
17	1.679	85.2	291	14.8	1.970	61.6	38.4
18	900	84.9	160	15.1	1.060	61.1	38.9
19	238	90.2	26	9.8	264	68.6	31.4
20	407	86.6	63	13.4	470	63.4	36.6
21	260	87.3	38	12.7	298	64.3	35.7
22	747	85.6	126	14.4	873	62.0	38.0
23	313	86.0	51	14.0	364	62.6	37.4
Total	8.574	86.03	1.392	13.97	9.966	62.62	37.38

iii. *The paternity material*

From this source data have been obtained for 390 individuals (317 for the Rh-system).

The A_1A_2B0-system

The material was divided into three subsamples (cf. Table 52).

TABLE 52. *A_1A_2B0 groups and gene frequencies.*

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	P_1	P_2	q	r	p+q+r
1, 2, 3	47	7	9	4	0	43	110	0.02	26.7	4.5	6.1	62.7	99.85
4, 5, 7	48	13	19	10	2	53	145	0.83	22.4	7.0	11.3	59.3	101.33
6	53	14	10	8	3	47	135	0.78	25.7	9.0	8.0	57.3	102.11
Total	148	34	38	22	5	143	390	2.32	24.8	6.9	8.6	59.7	101.14

For the genes A, B, and 0 no certain differences can be proved. The frequency of the gene A_2 is found to increase in eastern Dalecarlia, which borders the southern part of Gävleborg county, where the A_2-frequencies reach about 10 per cent. For the difference between subregions 1—5 and 6, 7, of the relative frequency A_2+A_2B, χ^2 is 4.33, 1 d.f., $0.05>P>0.02$.

This material also shows high B-frequencies, rising above 10 per cent in southern Dalecarlia.

The Rh-system

No significant heterogeneity exists in the group frequencies.

The frequency of D-negative individuals is higher in this material than in the blood donor material ($\chi^2=12.60$, 1 d.f., $0.001>P$). Most of the individuals in the paternity material came from southern Dalecarlia, where the frequency of D-negative individuals may be higher. The difference may therefore be due to an underrepresentation in the paternity material of individuals from northern Dalecarlia.

No significant heterogeneity is found for the frequencies of C-, D-, and E-negative individuals. In subregions 4, 5, and 7 a higher E-frequency is found, presumably associated with a similar value in the neighbouring county of Gävleborg. In these two areas the E-frequencies are above 20 per cent such as are otherwise found only in Lapland.

TABLE 53. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	Rh-	n
1. 2, 3	42	12	14	0	2	0	15	85
%	49.4	14.1	16.4	0	2.5	0	17.6	100
4, 5, 7	59	17	28	1	0	2	16	123
%	48.0	13.8	22.8	0.8	0	1.6	13.0	100
6	55	16	16	2	0	1	19	109
%	50.5	14.7	14.7	1.8	0	0.9	17.4	100
Total	156	45	58	3	2	3	50	317
%	49.21	14.19	18.30	0.95	0.63	0.95	15.77	100

TABLE 54. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1, 2, 3	55.2	44.8	41.7	58.3	16.6	83.4	85
4, 5, 7	61.8	38.2	38.2	61.8	21.4	78.6	123
6	57.2	42.8	41.0	59.0	16.5	83.5	109
Total	58.35	41.65	40.02	59.98	18.41	81.59	317

The MN-system

The consistency of the material is satisfactory.

With the same classification of the material as that used for earlier systems, we obtain the following frequencies:

TABLE 55 a. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1, 2, 3	31	62	17	110	2.34	56.4	43.6
4, 5. 7	48	73	24	145	0.18	58.3	41.7
6	48	65	22	135	0.000	59.7	40.3
Total	127	200	63	390	1.14	58.21	41.79

The differences between the regions are not significant. A drop of the M-frequencies towards the northwest may be observed. The frequency distribution can best be studied by a comparison of subregions 2, 4, and 5 with the subregions 1, 3, 6, and 7.

TABLE 55 b. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
2, 4, 5	38	56	13	107	0.08	61.6	38.4
1, 3, 6, 7	89	144	50	283	0.38	56.7	43.3
Total	127	200	63	390	1.14	58.21	41.79

Subregions 2, 4, and 5 roughly represent the area characterized by higher B-frequencies. Comparing this area with the rest of Dalecarlia we also find an increase of the M-frequency which, however, is not significant. Since the Finns are characterized by high frequencies for B and M the results for both the AB0- and MN-systems suggest traces of Finnish influence in Dalecarlia.

The P-system

The frequencies seem to be lowest in the eastern part of the area, agreeing with the adjoining county of Gävleborg. The variation between the subregions is, however, not significant. The greatest difference is obtained from a com-

TABLE 56. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1, 2, 3	80	72.7	30	27.3	110	47.8	52.2
4, 5, 7	107	73.8	38	26.2	145	48.8	51.2
6	106	78.5	29	21.5	135	53.6	46.4
Total	293	75.12	97	24.88	390	50.12	49.88

parison of subregions 1, 2, 4, and 5 with subregions 3, 6, and 7; i.e., of the western with the eastern parts of the area. The percentage of P-negative individuals is 29.7 per cent in the west and 21.9 per cent in the east ($\chi^2=2.94$, 1 d.f., $0.1>P>0.05$).

iv. *Summary*

The A-frequencies were highest in the eastern and western parts of the area, the A_2-frequency highest in the east. B-frequencies were lower in the east, and, as a rule, above 10 per cent in the central parts. The 0-frequencies were highest in an area stretching obliquely across Dalecarlia (corresponding roughly to the line Siljan—Dalälven). The variations of the frequencies of the genes C, D, E, M, and P were not significant.

7. Main region VII. The Mälar district

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

LUNDMAN has made some as yet unpublished local investigations in Uppland (personal communication). Together with FLODSTRÖM's data and certain information from "The Racial Characters . . ." these investigations give a fairly good idea of the anthropometrical characteristics of the area.

According to LUNDMAN (1945) the stature in Uppland is similar to that in Dalecarlia. The cephalic index of males is 79.8. From the data in the work by FÜRST and RETZIUS (1902) LUNDMAN has calculated that the two year classes of conscripts from Uppland have a different cephalic index, probably due to the fact that the examination in one of the years did not include the regiment of Uppland. The cephalic index for Uppland county is given by LUNDBORG and LINDERS (1926) as 78.1. According to LUNDMAN, the variations in the material from Uppland are greater than for the rest of Sweden. Individual values of 90 for the cephalic index are not rare. The face breadth is very considerable — on the average 141.4 mms. for men of military age. Concavity of the nasal bridge is commoner than in Dalecarlia. The color of the eyes is light throughout, and the frequency of males with brown eyes is only 1.5 per cent. Red hair is rare. In his summary LUNDMAN writes, "Racially the east-Baltic blood in Uppland is certainly not inconsiderable. The similarity between my material from Uppland and western Estonia is particularly impressive (see Table 57)."* In Södermanland the stature approximates the Swedish average, while the cephalic index is reported to be low (75—76). The color of the eyes is, furthermore, relatively light. The area is referred by LUNDMAN to that of the central Scandinavian ethnic stock.

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

The material for the northern part of the area (the counties of Stockholm, Uppsala, and part of Västmanland) has been obtained from the infantry regi-

* Translated from Swedish.

ment at Uppsala (I: 8). By fusion of parishes in the original classification, 17 subregions have been formed.

Regional classification

Subregion	Parishes
1	Älvkarleby, Västland, Tolfta, Söderfors, Hållnäs, Österlöfsta
2	Börstil, Gräsö, Valö, Hökhuvud, Forsmark, Singö
3	Dannemora, Tegelsmora, Film, Morkarla, Skäfthammar
4	Harg, Edebo, Häverö, Väddö
5	Viksta, Björklinge, Ärentuna, Lena, Åkerby, Jumkil, Vendel, Tensta, Bälinge, Skuttunge, Vaksala, Danmark, Börje, Upps.-Näs, Vänge, Läby
6	Alunda, Ekeby, Stavby, Tuna, Rasbo, Rasbokil, Faringe, Bladåker
7	Söderbykarl, Estuna, Lohärad, Malsta, Husby-Lyhundra, Skederid, Rimbo, Rö, Fasterna, Lagga, Östuna, Husby-Långhundra, Närtuna, Gottröra, Kårsta, Skepptuna, Lunda, Vidbo, Markim, Orkesta, Frösunda
8	Rådmansö, Österåker, Riala, Länna, Roslags-Kulla, Roslags-Bro, Vätö, Frötuna, Össeby-Garn, Vada
9	Almunge, Knutby, Ununge, Edsbro
10	Alsike, Knivsta, Odensala, Husby-Ärlinghundra, Norrsunda, Vassunda, Haga, St. Per, Skånela, Fresta, Angarn, Hammarby, Vallentuna, Ed
11	Hacksta, Löt, Veckholm, Torsvi, Kungs-Husby, Härkeberga, Litslena, Husby-Sjutolft, Villberga, Lillkyrka, Boglösa, Vallby, Arnö, Kalmar, Övergran, Yttergran, Häggeby, Håtuna, Skokloster, Håbo-Tibble, Bro and Lossa, V. Ryd, Stockholms-Näs, Ekerö, Munsö, Adelsö, Sånga, Skå
12	Västerfärnebo, Kumla, Kila, Sala rural community, Möklinta
13	Skinnskatteberg, Gunnilbo, Hed, Norberg, Västanfors, Karbenning, Västervåla
14	Tillinge, Svinnegarn, Enköpings-Näs, Teda, Sparrsätra, Bred, Vårfrukyrka, Västerlöfsta, Enåker, Norrby, Tärna, Simtuna, Altuna, Frösthult, Torstuna, Härnevi, Östersunda, Vittinge
15	Tierp
16	Östervåla, Nora, Harbo, Huddunge
17	Långtora, Nysätra, Biskopskulla, Fröslunda, Giresta, Fittja, Hjälsta, Holm, Kulla, Gryta, Balingsta, Hagby, Ramsta, Västeråker, Dalby, Skogs-Tibble, Åland.

The consistency of the total material and of all constituent areas is satisfactory.

The A-frequencies vary between 28.0 per cent in subregion 8, and 34.1 per cent in subregions 9 and 15. No significant heterogeneity exists for A+AB ($\chi^2=4.57$, 16 d.f., $P>0.99$).

The average for the entire area is 31.5 per cent. This agrees well with MOURANT's isarithmic ring for 30 per cent around the region of Lake Mälaren.

Significant heterogeneity is found for B+AB ($\chi^2=46.39$, 16 d.f., $P<0.001$). The high B-frequencies are concentrated in the coastal region. Subregion 2 showed a maximum of 13.5 per cent. Subregions 3 and 4, furthermore, show frequencies above 10 per cent. The lowest values are found in northern Upp-

TABLE 57. *AB0 groups and gene frequencies in Uppland and part of Västmanland.*

(Conscript material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+p+r
1	225	40	16	192	473	0.15	30.0	6.1	63.9	99.79
2	107	42	16	67	232	1.27	31.7	13.5	54.8	98.59
3	98	35	21	91	245	1.81	28.1	12.1	59.8	101.41
4	111	41	10	77	239	3.46	30.0	11.4	58.6	98.00
5	192	33	26	150	401	1.91	32.6	7.7	59.7	99.02
6	119	35	16	105	275	0.03	28.6	9.7	61.7	100.19
7	212	38	23	147	420	0.21	33.6	7.5	58.9	100.32
8	71	13	10	73	167	2.59	28.0	7.1	64.9	101.52
9	137	25	16	92	270	0.26	34.1	7.9	58.0	100.46
10	78	19	6	71	174	0.34	28.2	7.4	64.4	99.40
11	108	26	9	74	217	1.14	32.3	8.4	59.3	98.93
12	144	31	23	116	314	2.62	31.4	8.9	59.7	101.37
13	147	35	11	114	307	1.52	30.5	7.8	61.7	99.04
14	287	55	27	188	557	0.24	34.0	7.6	58.4	99.70
15	161	23	7	107	298	2.78	34.1	5.2	60.7	99.06
16	206	51	18	133	408	2.49	33.0	8.9	58.1	98.79
17	82	21	9	67	179	0.02	29.9	8.8	61.3	99.84
Total	2.485	563	264	1.864	5.176	0.415	31.5	8.4	60.1	99.87

land, in subregions 1 and 15. The northern Uppland area is connected with lower B-frequency areas in the southwestern part of Gävleborg county and the eastern part of Kopparberg county. We have noted above a higher B-frequency in the Gävleborg coastal region. These higher B-frequencies are probably associated with the high B-frequencies in the coastal region of Uppland.

The concentration of high B-frequencies along the northern coastal region seem to indicate an immigration of eastern elements. It is a reasonable supposition that such an immigration occurred via Åland.

The northern coastal region has probably undergone a gradual increase of B-frequencies. Relatively high B-frequencies (above 10 per cent) have repeatedly been found in parts of eastern Sweden, in Dalecarlia, and in Jämtland. We may therefore discard the earlier concept of the Baltic Sea and the Gulf of Bothnia as an effective serological boundary for B-frequencies. (See Map 17.)

No significant heterogeneity exists for the 0-group ($\chi^2=22.51$, 16 d.f., $0.2>P>0.1$).

The frequencies vary between 54.8 per cent in subregion 2, and 64.9 per cent in subregion 8. The average for the entire area is 60.1 per cent. The results agree with MOURANT's earlier map.

For Södermanland, the material has been obtained from the regiment at Strängnäs (P: 3). Cf. Table 58.

Map 17. Frequencies of the A, B and 0 genes in Uppland and part of Västmanland. (Conscript material.)

This material shows a pronounced inconsistency with a deficiency for AB ($\chi^2=13.79$, 1 d.f., $P<0.001$).

TABLE 58. *AB0 groups and gene frequencies (Södermanland).*

A	B	AB	0	n	χ^2	p	q	r	p+q+r
3.900	911	358	2.912	8.081	13.79	31.4	8.2	60.4	99.41

ii. *The blood donor material*

The AB0-system

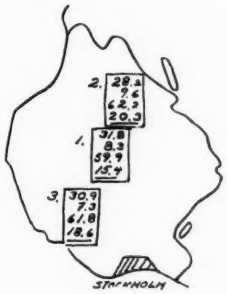
From the blood donor campaign in Uppsala county, data on 1,601 blood donors have been obtained. The determinations were made at the University Hospital, Division of Clinical Chemistry, at Uppsala under the supervision of Dr. P. L. ADNER. Most of the individuals examined came from the city of Uppsala. A regional division into three samples was made.

TABLE 59. *AB0 groups and gene frequencies.*

(Blood donor material, Uppland)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1. Uppsala, Storvreta	575	128	62	427	1.192	0.03	31.8	8.3	59.9	99.93
2. Österbybruk, Tierp, Örbyhus, Gimo	96	26	17	93	232	2.21	28.2	9.6	62.2	101.42
3. Bålsta, Örsundsbro	83	15	10	69	177	0.73	30.9	7.3	61.8	100.85
Total	754	169	89	589	1.601	0.33	31.1	8.4	60.5	100.21

The consistency of the material is satisfactory.



Map 18. Frequencies of the A, B and 0 genes and frequency of Rh-negative individuals in Uppland. (Blood donor material.)

The AB0-system shows no significant heterogeneity. The frequencies of the gene A vary relatively little, i.e., they lie around 30 per cent. The B-frequencies show an increase from south to north and northeast. Both frequencies agree with those of the conscript material. (See Map 18.)

From Södermanland's blood donor campaign, conducted by Dr. GUNNAR BRANTE, the following data for AB0 were obtained.

TABLE 60. *AB0 groups and gene frequencies (Södermanland).*

A	B	AB	0	n	χ^2	p	q	r	p+q+r
2.395	503	275	1.769	4.942	0.85	32.1	8.2	59.7	100.19

The conscript material (regiment P: 3) showed marked inconsistency, whereas this material is satisfactory. The B-frequency is the same in both series. In that of the conscripts, however, the A-frequency is 31.4 per cent, and the 0-frequency 60.4 per cent. In the conscript series the error consists in a deficiency of AB which probably has been classified as B. This does not produce a change in the B-frequency, but lowers the A-frequency, and raises the 0-frequency. Thus, it is probable that the lower A-frequency and the higher 0-frequency in the conscript material depend mainly on errors of serological technique.

The Rh-system

The frequencies of D-positive and D-negative individuals in Uppland are shown in Table 61.

The northernmost population has more than 20 per cent of D-negative individuals. No significant heterogeneity exists, however, for the frequency of D-negative individuals ($\chi^2=3.34$, 2 d.f., $0.2>P>0.1$).

In Södermanland the frequency of D-negative individuals is 16.03 per cent (n=4,942).

TABLE 61. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*

(Blood donor material, Uppland)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	1.008	84.6	184	15.4	1.192	60.8	39.2
2	185	79.7	47	20.3	232	54.9	45.1
3	144	81.4	33	18.6	177	56.9	43.1
Total	1.337	83.51	264	16.49	1.601	59.40	40.60

iii. *The paternity material*

From this area, data have been obtained for 3,135 individuals (2,477 for the Rh-system). The material has been divided into 7 part samples. (Subregions 4, 5, and 6 in the original classification have been merged.)

The A_1A_2B0-system

The total material and one of the constituent areas showed a significant inconsistency. The discrepancy consists in an excess of AB, mainly in the Stockholm region (subregion 7).

The frequency of A+AB displays homogeneity ($\chi^2=0.33$, 6 d.f., $P>0.99$). The frequency of the gene A lies somewhat above 30 per cent, and that of gene 0 at about 60—61 per cent, which agrees with the two other series of data.

The frequency of A_2+A_2B shows a significant heterogeneity ($\chi^2=15.08$, 6 d.f., $0.02>P>0.01$). Higher frequencies are found in subregions 2, 3, 7, and 8, in the centre of the area. This area may be considered a continuation of the high frequency region in southern Gävleborg and in eastern Dalecarlia. Along the coastal region and in the west are found on the other hand, lower frequencies. The lower frequencies in the west adjoin the low frequency area in western Dalecarlia. The frequency of B+AB shows no significant heterogeneity

TABLE 62. *A_1A_2B0 groups and gene frequencies.*

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1	26	3	6	1	0	20	56	1.24	28.3	3.9	6.5	61.3	98.09
2	84	28	24	5	3	91	235	0.31	21.3	8.9	7.2	62.6	99.53
3	113	32	20	14	3	134	316	3.03	22.5	7.5	6.0	64.0	101.20
4, 5, 6	48	5	12	4	2	40	111	0.001	27.1	4.5	8.4	60.0	100.05
7	749	217	202	89	36	799	2.092	5.71	22.5	8.2	8.1	61.2	100.73
8	72	20	23	10	3	55	183	0.005	25.7	9.0	10.4	54.9	99.90
9	61	6	16	9	0	50	142	0.08	28.8	3.0	9.2	59.0	100.37
Total	1.153	311	303	132	47	1.189	3.135	5.61	23.1	7.8	8.0	61.1	100.59

(χ^2=5.76, 6 d.f., 0.5>P>0.3). (In the northern part of the area the conscript material shows a significant heterogeneity for B+AB.) This material also, however, suggests that the higher frequencies are concentrated in the east.

The 0-frequencies are around 60 per cent with no significant variation.

The Rh-system

The frequencies of D-negative individuals are relatively low and uniform. For the difference of D-negative individuals between subregions 8 and 9 (northern and southern Södermanland) χ^2 is 4.72, 1 d.f., 0.05>P>0.02.

TABLE 63. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	Rh-	n
1	22	4	13	0	0	0	6	45
%	48.9	8.9	28.9	0	0	0	13.3	100
2	107	29	30	2	0	1	24	193
%	55.5	15.0	15.6	1.0	0	0.5	12.4	100
3	117	56	35	2	3	2	32	247
%	47.3	22.7	14.2	0.8	1.2	0.8	13.0	100
4, 5, 6	39	16	11	2	0	0	11	79
%	49.4	20.3	13.9	2.5	0	0	13.9	100
7	863	234	281	24	12	3	216	1.633
%	52.9	14.3	17.2	1.5	0.7	0.2	13.2	100
8	74	24	29	2	1	0	28	158
%	46.8	15.2	18.4	1.3	0.6	0	17.7	100
9	65	23	20	2	1	0	11	122
%	53.3	18.9	16.4	1.6	0.8	0	9.0	100
Total	1.287	386	419	34	17	6	328	2.477
%	51.96	15.58	16.92	1.37	0.69	0.24	13.24	100

TABLE 64. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1	63.5	36.5	35.0	65.0	21.1	78.9	45
2	64.1	35.9	45.8	54.2	17.1	82.9	193
3	61.3	38.7	46.3	53.7	21.0	79.0	247
4, 5, 6	62.7	37.3	45.0	55.0	18.9	81.1	79
7	62.5	37.5	43.3	56.7	17.4	82.6	1.633
8	57.2	42.8	38.8	61.2	18.5	81.5	158
9	68.7	31.3	48.0	52.0	19.6	80.4	122
Total	62.36	37.64	43.65	56.35	17.38	82.62	2.477

For the CDE-group a significant difference exists between subregions 3, 4, 5, and 6 and the rest of the area ($\chi^2=12.00$, 1 d.f., $P<0.001$).

The MN-system

The consistency of the material is not satisfactory for subregions 1 and 9.

TABLE 65. *MN groups and gene frequencies.*

Subregions		MM	MN	NN	n	χ^2	M-gene	N-gene
1	n	11	36	9	56	**4.62**	51.8	48.2
2	n	78	102	55	235	0.36	54.9	45.1
3	n	104	161	51	316	0.74	58.4	41.6
4, 5, 6	n	31	58	22	111	0.30	54.5	45.5
7	n	691	1.000	401	2.092	1.34	56.9	43.1
8	n	61	96	26	183	1.41	59.6	40.4
9	n	52	57	33	142	**4.73**	56.7	43.3
Total		1.028	1.510	597	3.135	0.36	56.88	43.12

In all regions the M-frequencies are below 60 per cent. There is no significant variation between the regions.

With relatively high B-frequencies also relatively high M-frequencies might have been expected in this area since these two features indicate an eastern influence. The high frequencies of B and M in northern Sweden are probably due to elements of east Finnish tribes which have higher M-frequencies than the western Finns and the Estonians. The relatively low M-frequencies in this area indicate that the element with higher B-frequencies found here may be derived also from populations other than the Finns.

The P-system

Subregional frequencies are given in Table 66. The frequency of P-negative individuals is homogeneous ($\chi^2=2.63$, 6 d.f., $0.9>P>0.8$). Within the area as

TABLE 66. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1	45	80.4	11	19.6	56	57.7	42.3
2	183	77.9	52	22.1	235	53.0	47.0
3	234	74.1	82	25.9	316	49.1	50.9
4, 5, 6	84	75.7	27	24.3	111	50.7	49.3
7	1.609	76.9	483	23.1	2.092	51.9	48.1
8	136	74.3	47	25.7	183	49.3	50.7
9	111	78.2	31	21.8	142	53.3	46.7
Total	2.402	76.62	733	23.38	3.135	51.65	48.35

a whole the frequency of the gene P is relatively low. In the eastern parts of the area, subregions 3—8, the frequencies appear still lower.

iv. *Summary*

The A-frequencies are relatively high and uniform. The A_2-frequencies are highest in the central parts. The B-frequencies are highest in the northern coastal region. The genes C, D, E, M, and P show no significant variation.

8. Main region VIII. The Väner provinces

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

Region VIII is made up of the counties located around Lake Vänern. Earlier anthropometrical maps by LUNDMAN characterize the Lake Väner area, especially the province of Dalsland by tall stature. Throughout most of the region the cephalic index is moderate (77—78). In Dalsland, however, the index is lower (75—76), and in the central parts of the county of Skaraborg somewhat higher (78—79). These two regions are, however, said to show a higher percentage (97—98 per cent) of light-colored eyes than the neighboring regions. LUNDMAN (1957) has made a special examination of the descendants of the seventeenth century Finnish immigrants to Värmland and adjacent regions. He found that the mixed Finnish population differs only slightly from the "pure" Swedish population. In his classification of the ethnic stocks LUNDMAN draws the boundary between the southwest Swedish "Götic" stock and the central Scandinavian stock obliquely across region VIII. According to my own regional classification (see Map 19), this boundary would run roughly between subregions 7 and 8, through subregion 3, and finally between subregions 1 and 2.

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

Data for Värmland are available on 833 conscripts from the infantry regiment (I: 2) at Karlstad. The frequencies are 29.8, 7.7, and 62.5 per cent for genes A, B, and 0, respectively. For the artillery regiment (A: 9) at Kristinehamn (n=2,167) the frequencies are 30.8, 7.6, and 61.6 per cent. The results are in good agreement, and indicate a medium frequency of the three genes in Värmland.

For the county of Örebro there is a series from the local infantry regiment (I: 3), comprising 832 individuals examined. Here the gene frequencies were 32.9, 9.1, and 58.0 per cent. The relatively high B-frequency is related to the corresponding areas in Dalecarlia and the region of Lake Mälaren, with high frequencies for gene B.

The Västergötland series is represented by records of 3,493 persons belonging to the Karlsborg regiment (Lv: 1). Here the gene frequencies are 31.6, 8.1, and 60.3 per cent. There are further data from the Borås regiment (I: 15),

giving 29.1, 7.1, and 63.8 per cent for genes A, B, and 0, respectively. Here the 0-frequencies are somewhat higher, as might be expected from the unit's more western position. The material, containing information about the parishes of birth, has been regionally classified according to the same system as adopted for the paternity material.

The gene frequencies in the different regions are seen in Table 67. Consistency for the total material and for all constituent areas is satisfactory. Some of the primary regions have been merged.

TABLE 67. *AB0 groups and gene frequencies.*

(Conscript material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	91	18	6	66	181	0.77	32.0	7.0	61.0	99.13
2	72	18	4	78	172	0.81	25.5	6.7	67.8	99.23
3	77	21	9	57	164	0.10	31.2	9.6	59.2	99.61
4	162	36	19	110	327	0.0003	33.2	8.8	58.0	99.98
5, 6, 7	406	92	52	282	832	0.30	32.9	9.1	58.0	100.26
8	276	74	30	176	556	1.75	33.1	9.9	57.0	99.05
9, 10	151	27	15	109	302	0.07	32.9	7.2	59.9	100.21
11	119	31	9	106	265	0.95	28.2	7.9	63.9	99.21
12	101	16	7	91	215	0.003	29.5	5.5	65.0	100.04
13	112	36	11	123	282	0.20	25.0	8.7	66.3	99.66
14	44	9	7	65	125	3.80	22.9	6.5	70.6	101.79
Total	1.611	378	169	1.263	3.421	0.03	30.7	8.4	60.9	99.84

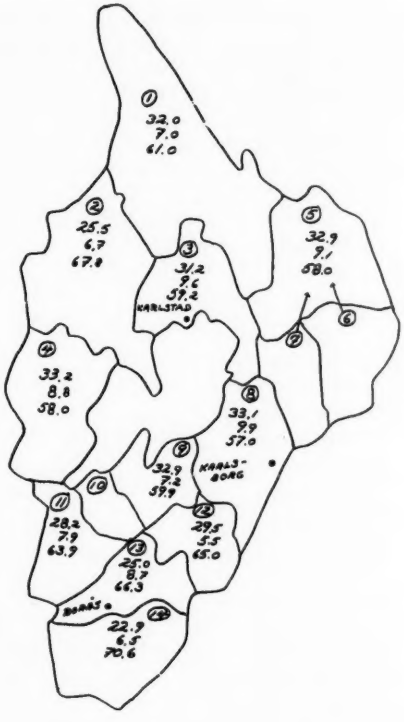
A significant heterogeneity exists for the frequency of A+AB ($\chi^2=59.87$, 10 d.f., $P<0.001$). The lowest frequencies are found in southern Västergötland and western Värmland. The difference between the northeastern and southwestern parts of the area roughly corresponds to LUNDMAN's anthroposystematical classification (cf. Map 2).

There is no significant heterogeneity for B+AB within the total area ($\chi^2=14.98$, 10 d.f., $0.2>P>0.1$). A significant difference ($\chi^2=6.75$, 1 d.f., $0.01>P>0.001$) exists, however, between subregions 5—8 (Närke and jurisdictional district of Vadsbo) and subregions 9—14 (Östergötland minus the jurisdictional district of Vadsbo). Thus a boundary is suggested somewhere between Närke and Västergötland with respect to the frequencies of B as well as A.

A significant heterogeneity exists for the frequency of the 0-group ($\chi^2=37.54$, 10 d.f., $P<0.001$).

In Västergötland the 0-frequencies gradually rise toward the south. In the eastern part of subregion 14 (jurisdictional district of Kind) the 0-frequency is about 77 per cent (n=69). The AB0-frequencies in southern Västergötland resemble those of Ångermanland. (See Map 19.)

The part of the region which, according to LUNDMAN, is dominated by the southwest Scandinavian ethnical stock is characterized by relatively low frequencies of genes A and B, and high frequencies of gene 0.



Map 19. Frequencies of the A, B and 0 genes. (Conscript material.)

ii. *The blood donor material*

Through the help of Mrs. INGEGERD LARSSON, Karlstad Red Cross Counselor, I have obtained a compilation of the data from Värmland county. No blood donor campaigns have taken place in the counties of Skaraborg and Älvsborg, but an analysis of the Värmland data is given below.

The AB0-system

The material was originally distributed over 48 samples. Larger samples were obtained through combining geographically neighboring regions. Table 68 shows the data for these. The consistency of the total material is satisfactory. One of the constituent areas shows inconsistency with expected frequencies.

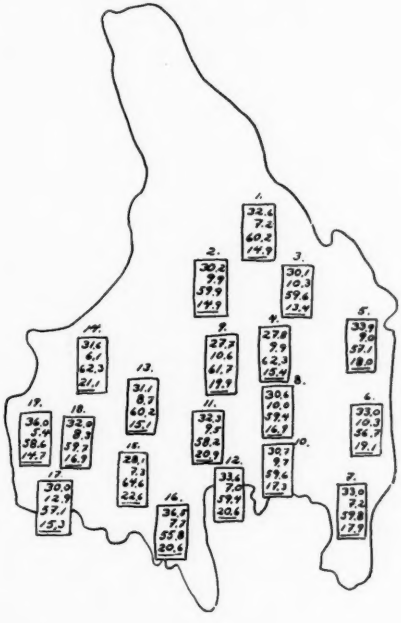
In Map 20 the frequencies for genes A, B, and 0 have been arranged vertically into frames, and centered according to the fused localities. The frequency for D-negative individuals is entered below the 0-frequency.

The A-frequencies were uniform and in most cases above 30 per cent. No significant heterogeneity is seen for the frequency of A+AB within the total

TABLE 68. *AB0 groups and gene frequencies.*
(Blood donor material, Värmland)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1. Ekshärad, Stöllet	88	16	7	63	174	0.002	32.6	7.2	60.2	99.95
2. Gräsmark, Lysvik, Torsby	109	33	11	82	235	1.03	30.2	9.9	59.9	98.98
3. Hagfors	62	20	6	46	134	0.99	30.1	10.3	59.6	98.65
4. Munkfors	137	37	15	117	306	0.55	27.8	9.9	62.3	99.39
5. Lesjöfors, Filipstad	73	14	12	51	150	1.46	33.9	9.0	57.1	101.57
6. Lundsberg, Nykroppa, Storfors	60	13	13	45	131	2.99	33.0	10.3	56.7	102.54
7. Ölme, Visnum, Kristinehamn	184	32	19	133	368	0.25	33.0	7.2	59.8	100.36
8. Molkom, Deje, Forshaga	136	39	17	104	296	0.12	30.6	10.0	59.4	99.69
9. Sunne, E. Ämtervik, W. Ämtervik	115	40	14	102	271	0.31	27.7	10.6	61.7	99.49
10. Skoghall, Skattkärr, Alster, Karlstad	488	126	73	386	1.073	1.91	30.7	9.7	59.6	100.65
11. Värmskog, Fagerås, Kil, Edsvalla, Högboda	166	44	17	112	339	1.15	32.3	9.5	58.2	99.08
12. Vålberg, Grums	90	11	14	69	184	5.49	33.6	7.0	59.4	102.34
13. Brunskog,Glava, Arvika	146	32	21	118	317	1.33	31.1	8.7	60.2	100.95
14. Charlottenberg, Köla, Åmotfors, Koppom	124	16	15	105	260	3.95	31.6	6.1	62.3	101.51
15. Långsered, Stavnäs, Stömne, Värml. Nysäter, Svanskog, Häljebol	104	24	9	97	234	0.08	28.1	7.3	64.6	99.77
16. Säffle	85	16	7	47	155	0.61	36.5	7.7	55.8	99.03
17. Lennartsfors, Sillerud, Blomskog	34	15	2	21	72	3.54	30.0	12.9	57.1	96.05
18. Årjäng	97	21	11	72	201	0.02	32.0	8.3	59.7	100.15
19. Töcksfors	53	7	3	32	95	0.26	36.0	5.4	58.6	99.34
Total	2.351	556	286	1.802	4.995	0.74	31.3	8.8	59.9	100.18

area ($\chi^2=14.13$, 18 d.f., $0.8>P>0.7$). The B-frequency for the total material is rather high, 8.8 per cent. The frequencies are higher in central and eastern Värmland, with a drop toward the southwest. A significant difference appears between the eastern part, subregions 1—11, and the western part, subregions 12—19 ($\chi^2=6.41$, 1 d.f., $0.02>P>0.01$). The conscript material was similar. High B-frequencies in central and eastern Värmland are geographically connected with the corresponding high frequency area in Dalecarlia and other adjacent counties. (See Map 20.)



Map 20. Frequencies of the A, B and 0 genes and frequency of Rh-negative individuals in Värmland. (Blood donor material.)

The Rh-system

The frequencies for D-positive and D-negative individuals are shown in Table 69 and Map 20. No significant heterogeneity exists for the frequency of D-negative individuals within the total material ($\chi^2=18.62$, 18 d.f., $0.5>P>0.3$). The lowest frequencies are encountered in the northern part of Värmland. A significant difference in the frequency of D-negative individuals is found between subregions 1—4 (in the north) and the rest of Värmland ($\chi^2=5.51$, 1 d.f., $0.02>P>0.01$).

The lower frequency area in northern Värmland geographically joins Dalecarlia, where frequencies are likewise low. The difference between northeastern and southwestern Värmland agrees with LUNDMAN's anthropometrical classification. The high frequencies of D-negative individuals occur in that

TABLE 69. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*

(Blood donor material, Värmland)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	148	85.1	26	14.9	174	61.4	38.6
2	200	85.1	35	14.9	235	61.4	38.6
3	116	86.6	18	13.4	134	63.4	36.6
4	259	84.6	47	15.4	306	60.8	39.2
5	123	82.0	27	18.0	150	57.6	42.4
6	106	80.9	25	19.1	131	56.3	43.7
7	302	82.1	66	17.9	368	57.7	42.3
8	246	83.1	50	16.9	296	58.9	41.1
9	217	80.1	54	19.9	271	55.4	44.6
10	887	82.7	186	17.3	1.073	58.4	41.6
11	268	79.1	71	20.9	339	54.3	45.7
12	146	79.4	38	20.6	184	54.6	45.4
13	269	84.9	48	15.1	317	61.1	38.9
14	205	78.9	55	21.1	260	54.1	45.9
15	181	77.4	53	22.6	234	52.5	47.5
16	123	79.4	32	20.6	155	54.6	45.4
17	61	84.7	11	15.3	72	60.9	39.1
18	167	83.1	34	16.9	201	58.9	41.1
19	81	85.3	14	14.7	95	61.7	38.3
Total	4.105	82.18	890	17.82	4.995	57.79	42.21

part of Värmland which is designated as the habitat of the southwest Scandinavian ethnical stock.

iii. *The paternity material*

From this area data have been obtained for 1,427 individuals (1,100 for the Rh-system). The material has been divided into 8 partial samples.

The A_1A_2B0-system

The consistency of the material is satisfactory. No significant heterogeneity exists for A+AB ($\chi^2=10.38$, 7 d.f., $0.2>P>0.1$). In subregions 7—12 the frequency A_2+A_2B is significantly higher than in subregions 5 and 6 in the northeast ($\chi^2=8.79$, 1 d.f., $0.01>P>0.001$), and also higher than in subregions 13 and 14 in the south ($\chi^2=5.84$, 1 d.f., $0.02>P>0.01$). Thus we find the highest A_2-frequencies, about 9 per cent, in northern Västergötland. Subregions 1, 5, and 6 with low A_2-frequencies border areas in Dalecarlia, Västmanland, and Södermanland likewise distinguished by low frequencies for A_2. Central Sweden contains, thus, a relatively large continuous area characterized by low A_2-frequencies.

No significant heterogeneity exists for B+AB ($\chi^2=3.64$, 7 d.f., $0.9>P>0.8$). In this material, too, eastern Värmland showed higher frequencies.

No significant heterogeneity was found for the frequency of the 0-group ($\chi^2=11.09$, 7 d.f., $0.2>P>0.1$).

In subregions 2—6, the central part of the area, the 0-frequency was significantly lower than elsewhere ($\chi^2=8.26$, 1 d.f., $0.01>P>0.001$). This material, also, showed high 0-frequencies for southern Västergötland.

TABLE 70. *A_1A_2B0 groups and gene frequencies.*

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1	36	9	15	2	1	47	110	0.02	19.2	5.9	8.6	66.3	98.82
3	81	23	30	9	2	78	223	0.47	22.8	7.8	9.7	59.7	99.29
2, 4	76	21	17	7	1	68	190	0.07	25.0	8.2	6.8	60.0	99.75
5, 6	131	18	33	9	1	97	289	2.55	28.3	4.8	7.8	59.1	98.64
7, 8	43	20	12	4	1	60	140	0.0001	18.5	9.8	6.2	65.5	99.99
9, 12	39	12	10	4	0	37	102	0.17	24.0	8.2	7.1	60.7	99.45
10, 11	46	19	13	7	2	65	152	1.59	19.2	9.0	7.4	64.4	101.28
13, 14	76	12	26	6	4	97	221	0.03	20.7	4.7	8.5	66.1	100.14
Total	528	134	156	48	12	549	1.427	1.26	22.8	6.9	7.9	62.4	99.60

The Rh-system

The frequencies of the different Rh-subgroups are given in Table 71. In subregions 9—12 the frequency of the D-negative individuals is significantly higher than in the rest of the area ($\chi^2=7.41$, 1 d.f., $0.01>P>0.001$). The highest frequencies of D-negative individuals are found in northern Västergötland (cf. this area also showed a significant rise of the A_2-frequencies).

The frequency of the gene E is relatively low. χ^2 for the difference in the frequencies of E-negative individuals between the subregions 9—12 and the rest of the area gave $\chi^2=5.28$, 1 d.f., $0.05>P>0.02$.

The MN-system

The consistency of the material is not satisfactory for subregions 13—14.

For the whole of the material the M-frequencies are relatively low and resemble those for the rest of central Sweden. In subregions 9—12 the M-frequency is fairly high (see Table 73). The difference between subregions 9 and 12 and the rest of the area is, however, insignificant ($\chi^2=3.08$, 1 d.f., $0.1>P>0.05$).

The P-system

No certain differences between the subregions could be established. The lowest frequencies of P-negative individuals are found in subregions 3, 9, and 12. The difference between these and the other regions gave $\chi^2=2.16$, 1 d.f., $0.2>P>0.1$.

TABLE 71. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	Rh-	Total
1	31	12	13	3	0	1	8	68
%	45.6	17.6	19.1	4.4	0	1.5	11.8	100
3	83	30	26	4	1	0	22	166
%	50.0	18.1	15.7	2.4	0.6	0	13.2	100
2, 4	79	21	24	2	1	1	22	150
%	52.6	14.0	16.0	1.3	0.7	0.7	14.7	100
5, 6	131	40	36	4	1	0	28	240
%	54.5	16.7	15.0	1.7	0.4	0	11.7	100
7, 8	57	19	18	0	0	0	14	108
%	52.7	17.6	16.7	0	0	0	13.0	100
9, 12	38	7	8	2	2	1	16	74
%	51.3	9.5	10.8	2.7	2.7	1.4	21.6	100
10, 11	64	14	18	2	1	1	23	123
%	52.1	11.4	14.6	1.6	0.8	0.8	18.7	100
13, 14	83	22	38	0	3	0	25	171
%	48.5	12.9	22.2	0	1.8	0	14.6	100
Total	566	165	181	17	9	4	158	1.100
%	51.46	15.00	16.45	1.55	0.82	0.36	14.36	100

TABLE 72. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1	63.5	36.5	39.3	60.7	21.4	78.6	68
3	62.8	37.2	44.1	55.9	18.6	81.4	166
2, 4	59.9	40.1	42.8	57.2	16.7	83.3	150
5, 6	65.2	34.8	46.7	53.3	17.3	82.7	240
7, 8	63.9	36.1	45.5	54.5	18.9	81.1	108
9, 12	49.3	50.7	39.6	60.4	11.5	88.5	74
10, 11	54.9	45.1	40.3	59.7	14.5	85.5	123
13, 14	59.5	40.5	39.3	60.7	19.4	80.6	171
Total	60.58	39.42	42.80	57.20	17.43	82.57	1.100

iv. *Summary*

A-frequencies are lowest in the southwest. The highest A_2-frequencies are found in northern Västergötland. B-frequencies are highest in the east, 0-frequencies in the southwest. The frequency of D-negative individuals is highest in western Värmland and northern Västergötland. The frequencies of the genes C, E, M, and P shows no significant variation.

TABLE 73. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1	37	53	20	110	0.02	57.7	42.3
3	65	121	37	223	2.61	56.3	43.7
2, 4	57	96	37	190	0.27	55.3	44.7
5, 6	85	141	63	289	0.10	53.8	46.2
7. 8	46	66	28	140	0.24	56.4	43.6
9, 12	40	53	9	102	0.21	65.2	34.8
10, 11	43	76	33	152	0.29	53.3	46.7
13, 14	65	125	31	221	5.56	57.7	42.3
Total	438	731	258	1.427	2.43	56.30	43.70

TABLE 74. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1	85	77.3	25	22.7	110	52.4	47.6
3	186	83.4	37	16.6	223	59.3	40.7
2, 4	152	80.0	38	20.0	190	55.3	44.7
5, 6	236	81.7	53	18.3	289	57.2	42.8
7, 8	114	81.4	26	18.6	140	56.9	43.1
9, 12	87	85.3	15	14.7	102	61.7	38.3
10, 11	121	79.6	31	20.4	152	54.8	45.2
13, 14	172	77.8	49	22.2	221	52.9	47.1
Total	1.153	80.80	274	19.20	1.427	56.18	43.82

9. Main region IX. Southeast Sweden

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

According to LUNDMAN (1946) the southern part of this region is characterized by several different small isolated groups. The northern part is called the inner-Scandinavian ethnical stock area, the southwestern part the southwest-Scandinavian stock area. In his classification of the ethnical stocks LUNDMAN divides Småland into four subgroups and supposes certain connections between these subgroups and groups in other locations.

1) The *east-Smålandic group*, corresponding roughly to subregions 8 and 14 on the map, is believed to be connected with the west-Finnish ethnical stock. 2) The *group of the gulf of Hanö* (subregions 13 and 15) — connected both with the population of the Danish islands and the ethnical stock of inner Scandinavia. 3) The *group of Värend* (approximately subregions 11 and 12) — connected with the Götic group in southwestern Sweden. Finally, 4) The *group of Njudung*, roughly subregion 7, connected with the ethnical stock of inner Scandinavia.

LUNDMAN's results were based on FLODSTRÖM's work (1926).

b) SEROLOGICAL INVESTIGATIONS

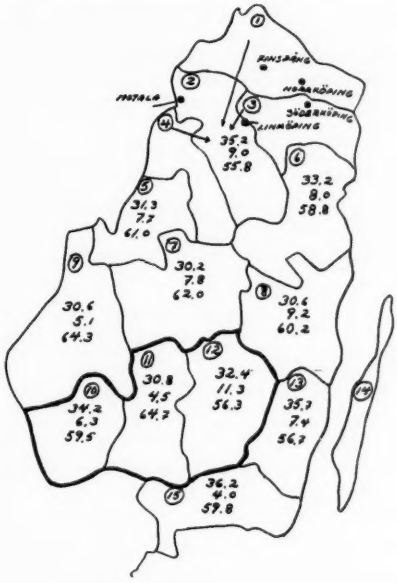
i. *The conscript material*

It was possible to sort out only a relatively small sample of conscripts born in Östergötland and it showed relatively high frequencies for A and B, and a low 0-frequency (see Table 75).

From both Småland and Blekinge data including information about the parish of birth have been obtained from the artillery regiment at Jönköping (A: 6) and from the infantry regiment (I: 18) on Gotland, where many con-

TABLE 75. *AB0 groups and gene frequencies.*
(Conscript material)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1—4. Östergötland	97	22	9	56	184	0.89	35.2	9.0	55.8	98.86
5. Tveta, Vista, N. Vedbo	95	18	12	77	202	0.90	31.3	7.7	61.0	100.92
6. N. Tjust, S. Tjust, Sevede, Vimmerby, Västervik	108	24	8	70	210	1.47	33.2	8.0	58.8	98.77
7. Västra, S. Vedbo, Östra	101	23	9	82	215	0.17	30.2	7.8	62.0	99.62
8. Aspeland, Tunalän, Handbörd, Stranda, Oscarshamn	79	17	15	69	180	3.52	30.6	9.2	60.2	102.09
9. Östbo, Västbo, Mo, Värnamo	88	13	5	74	180	0.10	30.6	5.1	64.3	99.74
10. Sunnebo	47	7	4	32	90	0.009	34.2	6.3	59.5	100.13
11. Kinnevald, Norrvidinge, Allbo, Växjö	94	10	7	82	193	0.71	30.8	4.5	64.7	100.62
12. Konga, Uppvidinge	86	24	16	61	187	0.69	32.4	11.3	56.3	101.06
13. S. Möre, N. Möre, Kalmar	142	19	21	94	276	**4.49**	35.7	7.4	56.9	101.90
14. Åkerbo, Slättbo, Runsten, Algutsrum, Möckleby, Gräsgård	22	3	1	18	44	—	—	—	—	—
15. Blekinge	116	12	4	71	203	0.99	36.2	4.0	59.8	99.24
Total	1.075	192	111	786	2.164	0.89	32.7	7.3	60.0	100.28



Map 21. Frequencies of the A, B and 0 genes. (Conscript material.) County of Kronoberg within the heavy line.

scripts from the mainland do military service. Table 75 contains data for the material distributed regionally according to parish of birth.

One of the constituent areas shows inconsistency. The results for the total material are satisfactory. No significant heterogeneity exists for the frequency of A+AB ($\chi^2=7.63$, 11 d.f., $0.8>P>0.7$). The frequency of A exceeded 30 per cent in all subregions (Map 21). MOURANT's map shows an isogene for 30 per cent around Lake Mälaren; it would now seem more correct to extend this isogene to include all of southeastern Sweden.

Significant heterogeneity was found for the frequency of B+AB ($\chi^2=27.05$, 11 d.f., $0.01>P>0.001$). In the northern and northeastern parts of the area the B-frequencies are higher, agreeing with LUNDMAN's hypothesis that the people from eastern Småland include east-Baltic elements. The northeastern area joins the high B-frequency region of central Sweden. Low B-frequencies are found in southwestern Småland. Low B-frequencies has previously been reported in western Småland by REIZ (quoted by STRENG, 1935). This series showed a B-frequency of 4.6 per cent (n=250).

The highest 0-frequencies are found in the southwestern part of the area. The difference between subregions 9, 10, and 11 (with relatively high 0-frequencies) and the remainder of the subregions is significant ($\chi^2=9.72$, 1 d.f., $0.01>P>0.001$).

The result agrees fairly well with LUNDMAN's hypothesis that western Småland and the Värend group have certain anthropological similarities with the Götic ethnic stock in southwestern Sweden (see Map 21).

ii. *The blood donor material*

Data from 3,846 individuals in Kronoberg county and for 3,580 individuals in Östergötland have been obtained. No blood donor campaigns have been conducted in Jönköping and Kalmar counties.

The AB0-system

The Östergötland material (Table 76) was derived mainly from the densely populated places. It has been divided into five partial populations whose positions are shown in Map 21. The consistency of the material is satisfactory.

TABLE 76. *AB0 groups and gene frequencies.*
(Blood donor material, Östergötland)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1. Söderköping	121	29	20	111	281	2.67	29.2	9.1	61.7	101.40
2. Motala	205	38	18	157	418	0.02	31.7	6.9	61.4	99.92
3. Finspång	83	25	17	84	209	2.93	27.5	10.5	62.0	101.76
4. Norrköping	671	116	64	521	1.372	1.33	31.8	6.9	61.3	100.41
5. Linköping	606	134	63	497	1.300	0.04	30.3	7.9	61.8	100.08
Total	1.686	342	182	1.370	3.580	1.22	30.8	7.6	61.6	100.25

No significant heterogeneity exists for the frequency of A+AB ($\chi^2=3.37$, 4 d.f., $0.5>P>0.3$). The A-frequencies average 30 per cent, and thus agree with those of the conscript material.

Significant heterogeneity was found for the frequency of B+AB ($\chi^2=11.98$, 4 d.f., $0.02>P>0.01$). The northern and eastern parts show the highest B-frequencies, and form a continuation of the higher B-frequency areas of eastern Småland, extending upward toward Lake Mälaren. Thus, B-frequencies higher than those of the inland characterize the entire east coast, from Kalmar in the south to Hälsingland in the north.

A very small variation could be shown for the 0-gene. All frequencies are between 61.3 and 62 per cent.

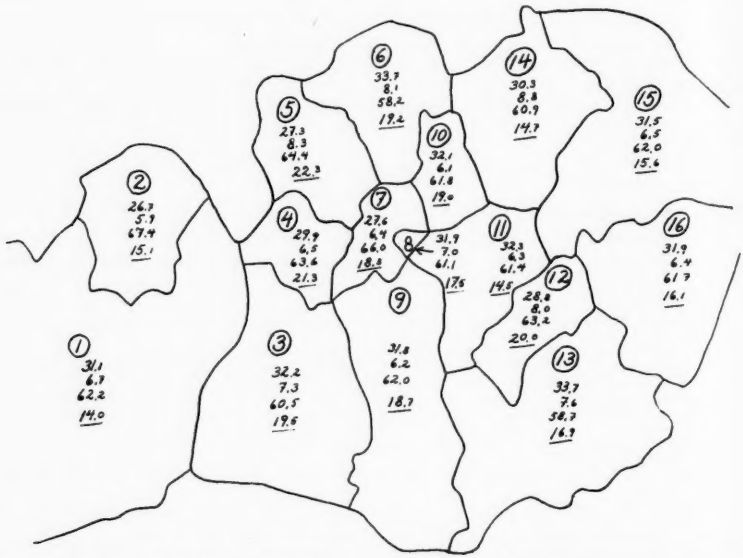
The blood donor material from Kronoberg county has been divided into 16 subsamples. The consistency of two of the constituent areas is not satisfactory. Names of certain densely populated places, as well as parish names, have been included in Table 77.

No significant heterogeneity exists for the frequency of A+AB ($\chi^2=20.91$, 15 d.f., $0.2>P>0.1$). Map 22 shows frequencies above 30 per cent concentrated in the eastern and southern parts of the county. Subregions 2, 4, 5, and 7, all with lower frequencies, are in the northwest, where a drop in A-frequencies might be expected. A comparison between subregions 2, 4, 5, and 7 and the remaining subregions gives $\chi^2=12.13$, 1 d.f., $0.001>P$.

The B+AB frequency shows homogeneity ($\chi^2=3.62$, 15 d.f., $P>0.99$). A comparison between subregions 5, 6, and 14 and the remaining subregions gives

TABLE 77. *AB0 groups and gene frequencies.*
(Blood donor material, Kronoberg)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1. Markaryd, Hallaryd, Strömsnäsbruk, Göteryd, Hamneda, Pjätteryd, Agunnaryd, Ryssby, Vrå	88	18	5	67	178	2.41	31.1	6.7	62.2	98.52
2. Lagan, Ljungby	61	13	3	62	139	0.76	26.7	5.9	67.4	99.21
3. Virestad, W. Torsås, Skatelöv, Vislanda	126	23	13	95	257	0.16	32.2	7.3	60.5	100.34
4. Hjortsberga, Alvesta	84	18	4	68	174	1.83	29.9	6.5	63.6	98.75
5. Älmhult, Öhr, Moheda	119	30	15	119	283	0.54	27.3	8.3	64.4	100.57
6. Lammhult, Asa, Tolg, Ormesberga, Tjureda, Bergslund	99	21	9	64	193	0.55	33.7	8.1	58.2	99.20
7. Öjaby, Bergunda, Öja	107	18	13	113	251	2.96	27.6	6.4	66.0	101.24
8. Växjö	522	89	59	410	1.080	2.67	31.9	7.0	61.1	100.66
9. Vederslöv, Tävelsås, Kalvsvik, Urshult	71	8	10	61	150	**4.58**	31.8	6.2	62.0	102.17
10. Söraby, Gårdsby	62	9	6	49	126	0.39	32.1	6.1	61.8	100.69
11. Hemmesjö, Furuby, E. Torsås, Uråsa	89	14	8	68	179	0.12	32.3	6.3	61.4	100.31
12. Nöbbele, Hovmantorp, Lessebo	67	16	7	60	150	0.0003	28.8	8.0	63.2	100.02
13. Tingsryd, Linneryd, Älmeboda, Långasjö, Väckelsång	67	9	10	50	136	**4.03**	33.7	7.6	58.7	102.49
14. Braås, Dädesjö, Skruv, Nottebäck	90	25	7	68	190	1.55	30.3	8.8	60.9	98.69
15. Åseda, Lenhovda, Älghult	80	12	9	66	167	1.09	31.5	6.5	62.0	101.02
16. Ryd, Kosta, Orrefors, Algutsboda	97	18	6	72	193	0.73	31.9	6.4	61.7	99.22
Total	1.829	341	184	1.492	3.846	2.31	30.9	7.1	62.0	100.32



Map 22. Frequencies of the A, B and 0 genes and frequency of Rh-negative individuals in the county of Kronoberg. (Blood donor material.)

$\chi^2=0.89$, 1 d.f., $0.5>P>0.3$. The somewhat higher frequencies in the northern part of the county are thus not significant. The conscript material showed the variation of gene B within Main Region IX to be significant. The boundary seems, however, to lie between northeastern and southwestern Småland, whereas within Kronoberg county the B-frequencies show homogeneity.

The 0-frequencies were higher towards the northwest. This agrees with those of the conscript material. The difference is, however, not significant.

The Rh-system

The frequency of D-negative individuals in Östergötland is shown in Table 78.

No significant heterogeneity exists for the frequency of D-negative individuals within the total material ($\chi^2=8.54$, 4 d.f., $0.1>P>0.05$). The Finspång and Linköping frequencies (central Östergötland) are higher than those of the other subregions ($\chi^2=8.32$, 1 d.f., $0.01>P>0.001$).

The Rh-data for Kronoberg county are shown in Table 79.

The frequencies of D-negative individuals are shown in Map 22 below the AB0-values.

No significant heterogeneity exists for the frequency of D-negative individuals ($\chi^2=12.39$, 15 d.f., $0.7>P>0.5$). A comparison between subregions 3—13 and 15 and the remaining subregions gives $\chi^2=5.97$, 1 d.f., $0.02>P>0.01$.

TABLE 78. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*
(Blood donor material, Östergötland)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	241	85.8	40	14.2	281	62.3	37.7
2	359	85.9	59	14.1	418	62.5	37.5
3	166	79.4	43	20.6	209	54.6	45.4
4	1.173	85.5	199	14.5	1.372	61.9	38.1
5	1.072	82.5	228	17.5	1.300	58.2	41.8
Total	3.011	84.11	569	15.89	3.580	60.14	39.86

TABLE 79. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*
(Blood donor material, Kronoberg)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	153	86.0	25	14.0	178	62.6	37.4
2	118	84.9	21	15.1	139	61.1	38.9
3	207	80.5	50	19.5	257	55.8	44.2
4	137	78.7	37	21.3	174	53.8	46.2
5	220	77.7	63	22.3	283	52.8	47.2
6	156	80.8	37	19.2	193	56.2	43.8
7	205	81.7	46	18.3	251	57.2	42.8
8	891	82.5	189	17.5	1.080	58.2	41.8
9	122	81.3	28	18.7	150	56.8	43.2
10	102	81.0	24	19.0	126	56.4	43.6
11	153	85.5	26	14.5	179	61.9	38.1
12	120	80.0	30	20.0	150	55.3	44.7
13	113	83.1	23	16.9	136	58.9	41.1
14	162	85.3	28	14.7	190	61.7	38.3
15	141	84.4	26	15.6	167	60.5	39.5
16	162	83.9	31	16.1	193	59.9	40.1
Total	3.162	82.22	684	17.78	3.846	57.83	42.17

Thus, in the central part of the county, the frequency of D-negative individuals is significantly higher. The highest frequencies are found in that population which LUNDMAN calls the "Värend group".

iii. *The paternity material*

From this region data have been obtained for 1,292 individuals (1,001 for the Rh-system). The data from the 15 original subregions have been fused into 8 larger samples.

The A_1A_2B0-system

The consistency of the material is satisfactory. The frequencies for total A are high, always exceeding 30 per cent, except in subregion 15. This confirms the earlier observation that A-frequencies above 30 per cent are found not only in the district around Lake Mälaren, but also in southeastern Sweden. Östergötland has the maximum frequency. This material had a lower A-frequency for subregion 15 (Blekinge) than the conscript material. The difference between the two sets of data is, however, not significant ($\chi^2=3.05$, 1 d.f., $0.1>P>0.05$).

No significant heterogeneity exists for the frequency of A+AB within the whole area ($\chi^2=13.05$, 7 d.f., $0.1>P>0.05$). In the southern part the A-frequencies are lowest. A comparison between subregions 13—15 and the remaining subregions gave $\chi^2=6.85$, 1 d.f., $0.01>P>0.001$.

No significant heterogeneity exists for the frequency of A_2+A_2B within the total material ($\chi^2=10.44$, 7 d.f., $0.2>P>0.1$). The A_2-frequencies are relatively high, exceeding 10 per cent in two cases.

There is a significant difference in the A_2+A_2B-frequencies between central Småland (subregions 7 and 11) and the rest of the region ($\chi^2=7.74$, 1 d.f., $0.01>P>0.001$).

The frequency of A_2+A_2B is, furthermore, significantly lower in Blekinge than in central Småland ($\chi^2=8.90$, 1 d.f., $0.01>P>0.001$). Blekinge belongs to LUNDMAN's anthropological group of the gulf of Hanö.

No significant heterogeneity exists for B+AB within the total area ($\chi^2=7.13$, 7 d.f., $0.5>P>0.3$).

As in the conscript material, the coastal area, i.e., subregions 1, 2, 6, 8, 13, and 14, shows a significantly higher B-frequency than the inland area ($\chi^2=7.12$, 1 d.f., $0.01>P>0.001$).

The frequency of the 0-group is higher in Blekinge than in the rest of the area ($\chi^2=6.84$, 1 d.f., $0.01>P>0.001$). Otherwise, the area had low 0-frequencies (below 60 per cent) typical of eastern Sweden.

TABLE 80. *A_1A_2B0 groups and gene frequencies.*

Sub-regions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1	81	24	21	10	4	77	217	0.59	23.7	9.0	8.4	58.9	100.78
2, 3	90	28	17	5	0	60	200	0.41	27.7	10.6	5.7	56.0	98.38
4, 5	69	15	10	3	2	52	151	1.75	27.9	7.3	5.1	59.7	98.70
7, 12	47	8	8	1	2	31	97	0.55	29.1	7.7	5.8	57.4	98.99
6, 8	52	16	15	5	3	50	141	0.01	22.8	9.3	8.5	59.4	100.14
9, 10, 11	49	16	7	3	4	42	121	1.05	24.3	11.8	6.0	57.9	101.25
13, 14	52	13	17	6	1	49	138	0.18	24.0	6.9	9.1	60.0	99.46
15	81	18	24	5	1	98	227	0.34	21.2	5.5	7.2	66.1	99.54
Total	521	138	119	38	17	459	1.292	0.67	24.7	8.4	7.0	59.9	99.69

The Rh-system

In subregions 2—5 the frequency of the CD-group is significantly lower than in the rest of the area ($\chi^2=6.86$, 1 d.f., $0.01>P>0.001$). In subregions 1—5 the frequency of the CDE-group is significantly higher than in the rest of the area ($\chi^2=9.71$, 1 d.f., $0.01>P>0.001$). The D-negative frequency is high, nearly 20 per cent, throughout the entire area. Only regions 13 and 14 show lower frequencies. A comparison between subregions 13 and 14 and the rest of the area gives $\chi^2=1.59$, 1 d.f., $0.3>P>0.2$. The results are in good agreement with those from the blood donor material of Kronoberg county (subregions 10—12). Östergötland's blood donor data also gave some high frequency samples (subregions 1—3). In subregion 2 (n=53) the D-negative frequency exceeded 30 per cent.

TABLE 81. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	Rh-	n
1	84	32	22	1	4	2	30	175
%	48.0	18.3	12.6	0.6	2.3	1.1	17.1	100
2, 3	62	27	22	2	1	0	29	143
%	43.3	18.9	15.4	1.4	0.7	0	20.3	100
4, 5	53	23	23	2	0	0	24	125
%	42.4	18.4	18.4	1.6	0	0	19.2	100
7, 12	42	9	13	2	0	0	15	81
%	51.9	11.1	16.0	2.5	0	0	18.5	100
6, 8	57	13	17	1	1	1	21	111
%	51.4	11.7	15.3	0.9	0.9	0.9	18.9	100
9, 10, 11	43	13	16	0	3	2	12	89
%	48.3	14.6	18.0	0	3.4	2.2	13.5	100
13, 14	59	12	20	0	1	2	12	106
%	55.7	11.3	18.9	0	0.9	1.9	11.3	100
15	92	17	24	1	3	0	34	171
%	53.8	9.9	14.0	0.6	1.8	0	19.9	100
Total	492	146	157	9	13	7	177	1.001
%	49.15	14.59	15.68	0.90	1.30	0.70	17.68	100

The frequencies of genes C, D, and E are shown in Table 82. The E-gene has lower frequencies in subregions 7, 12, and 15 in a northsouth tract crossing the centre of the area. A comparison between these and the other regions gave $\chi^2=5.42$, 1 d.f., $P \approx 0.02$.

The MN-system

The consistency of the material is satisfactory. In the coastal subregions, 13 and 14, M-frequency is above 60 per cent. B-frequencies in the coastal area

TABLE 82. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1	54.7	45.3	44.0	56.0	17.5	82.5	175
2, 3	54.2	45.8	39.1	60.9	18.9	81.1	143
4, 5	56.2	43.8	37.4	62.6	20.5	79.5	125
7, 12	57.0	43.0	39.2	60.8	14.6	85.4	81
6, 8	55.0	45.0	40.0	60.0	15.1	84.9	111
9, 10, 11	56.3	43.7	42.1	57.9	19.3	80.7	89
13, 14	62.5	37.5	42.6	57.4	17.6	82.4	106
15	53.4	46.6	41.3	58.7	12.8	87.2	171
Total	55.64	44.36	40.87	59.13	16.91	83.09	1.001

are also higher, two circumstances which suggest an eastern influence in eastern Småland. Blekinge has the lowest M-frequency. The difference between subregions 13 and 14 and subregion 15 is, however, not significant ($\chi^2=3.33$, 1 d.f., $0.1>P>0.05$).

TABLE 83. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1	67	108	42	217	0.02	55.8	44.2
2, 3	71	96	33	200	0.003	59.5	40.5
4, 5	46	75	30	151	0.0004	55.3	44.7
7, 12	28	51	18	97	0.37	55.2	44.8
6, 8	42	73	26	141	0.34	55.7	44.3
9, 10, 11	43	56	22	121	0.003	58.7	41.3
13, 14	50	67	21	138	0.03	60.5	39.5
15	62	111	54	227	0.10	51.8	48.2
Total	409	637	246	1.292	0.007	56.31	43.69

The P-system

The frequency of P-negative individuals is high in the northern part of the area and in subregions 7 and 12. A significant difference exists between subregions 4, 5, 7, and 12 and the rest of the area ($\chi^2=5.93$, 1 d.f., $0.02>P>0.01$). Thus, the inner parts of the area show lower P-frequencies. A comparison between subregions 9—11 (southwestern Småland) and subregions 7 and 12 (the central part) gives $\chi^2=4.07$, 1 d.f., $0.05>P>0.02$.

iv. *Summary*

The A-frequencies are highest in the north. The A_2-frequencies are highest in central Småland and in Östergötland. The B-frequencies are highest in the east, and the 0-frequencies in the southwest. The frequency of D-negative

TABLE 84. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1	171	78.8	46	21.2	217	54.0	46.0
2, 3	158	79.0	42	21.0	200	54.2	45.8
4, 5	111	73.5	40	26.5	151	48.5	51.5
7, 12	74	76.3	23	23.7	97	51.3	48.7
6, 8	113	80.1	28	19.9	141	55.4	44.6
9, 10, 11	105	86.8	16	13.2	121	63.7	36.3
13, 14	113	81.9	25	18.1	138	57.5	42.5
15	190	83.7	37	16.3	227	59.6	40.4
Total	1.035	80.11	257	19.89	1.292	55.40	44.60

individuals is high throughout the area and highest in Östergötland. The E-frequency is lowest in central Småland and in Blekinge. The frequencies of the genes C and M show no significant variations. The P-frequencies are lowest in Östergötland and central Småland.

LUNDMAN's detailed anthroposystematical subdivisions of Småland, based on anthropometrical data, have to a large extent been supported by the blood group investigations.

10. Main region X. Southwest Sweden

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

The region forms a narrow marginal zone in southwestern Sweden. The stature is tallest in Bohuslän, shortest in southeastern Scania. The cephalic index is lowest in Bohuslän, highest in southern Scania, and Scania has the darkest pigmentation. Except for eastern Scania, the whole population belongs to the southwest Scandinavian ethnical stock (LUNDMAN, 1946). An anthropometrical investigation was made by LUNDMAN (1952 d) on Tjörn Island in Bohuslän. He believes that elements of an Armenid-Mediterranean mixed population (the so-called Litoral race of CZEKANOWSKI and LUNDMAN) can be distinguished on this island.

b) SEROLOGICAL INVESTIGATIONS

i. *The conscript material*

Data for all military units within the region are given in Table 85.

The total data and those of two of the regiments show a significant inconsistency.

The material from Bohuslän and Halland could not be arranged according to birthplace. Only part of the Scania material contained information about the parishes of birth. A division has been made comprising different towns and the rural districts of Malmöhus and Kristianstad counties. The data for Scania are given in Table 86.

TABLE 85. *AB0 groups and gene frequencies of the regiments*

Regiments	A	B	AB	0	n	χ^2	p	q	r	p+q+r
I: 7 Ystad	1.091	251	109	921	2.372	0.53	29.8	7.8	62.4	99.80
I: 16 Halmstad	3.838	800	268	3.441	8.347	**7.45**	28.8	6.7	64.5	99.64
I: 17 Uddevalla	3.363	712	279	2.851	7.205	3.19	29.8	7.2	63.0	99.73
A: 2 Göteborg	2.297	474	238	2.029	5.038	2.77	29.4	7.3	63.3	100.30
A: 3 Kristianstad	1.979	459	155	1.770	4.363	**4.80**	28.6	7.4	64.0	99.58
Lv: 4 Malmö	429	90	44	359	922	0.15	30.2	7.6	62.2	100.17
Lv: 6 Göteborg	547	129	51	486	1.213	0.23	28.8	7.7	63.5	99.82
T: 4 Hässleholm	1.726	415	150	1.512	3.803	3.76	28.9	7.7	63.4	99.59
Total	15.270	3.330	1.294	13.369	33.263	**12.99**	29.2	7.2	63.6	99.75

TABLE 86. *AB0 groups and gene frequencies in Scania.*
(Conscript material)

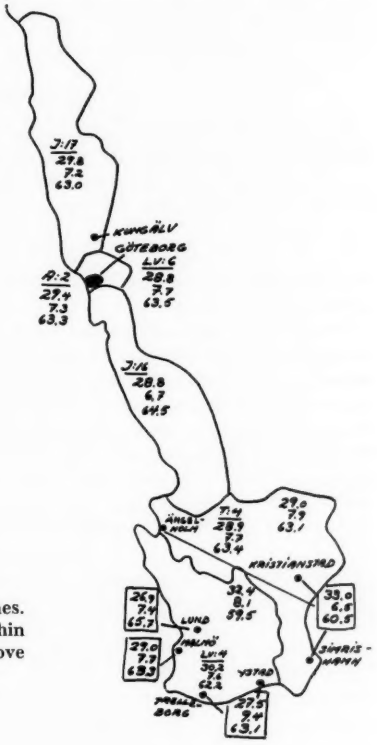
Towns	A	B	AB	0	n	χ^2	p	q	r	p+q+r
Kristianstad, Simrishamn, Ängelholm	57	10	4	40	111	0.21	33.0	6.5	60.5	99.43
Malmö	191	47	14	163	415	1.56	29.0	7.7	63.3	99.20
Lund	159	39	14	160	372	0.03	26.9	7.4	65.7	99.86
Trelleborg Ystad	103	30	14	99	246	0.20	27.5	9.4	63.1	100.40
Rural areas										
Malmöhus county	180	32	27	139	378	**3.92**	32.4	8.1	59.5	101.48
Kristianstad county	128	34	7	105	274	3.57	29.0	7.9	63.1	98.49

The total data from 5 different units have been used for the heterogeneity analysis. Their location is shown on Map 23. Bohuslän is represented by I: 17, the district of Göteborg by A: 2, Halland by I: 16, Kristianstad county by T: 4, and Malmöhus county by Lv: 4.

The frequency of A+AB shows homogeneity ($\chi^2=3.63$, 4 d.f., $0.5>P>0.3$).

The A-frequencies are generally somewhat below 30 per cent, but Malmöhus county forms an exception. Here the series for Lv: 4 and data from the rural districts show frequencies above 30 per cent. In the towns towards the south-west in Malmöhus county, however, the frequencies are somewhat lower. (On the map, town data have been set into frames, and the signs for the different military units have been entered above the corresponding information. Data from the rural districts are without special signs.)

The B+AB frequency shows homogeneity ($\chi^2=1.32$, 4 d.f., $0.9>P>0.8$).



Map 23. Frequencies of the A, B and 0 genes. (Conscript material.) Data for towns within frames, signs for different military units above the corresponding information.

The frequencies are generally between 7 and 8 per cent. Halland, however, has slightly lower frequencies, which may be associated with similar frequencies in western Småland.

In the two southernmost towns, the B-frequencies were 9.4 per cent. The difference between Ystad and Trelleborg, on one side, and, on the other, Scania's total data is not significant ($\chi^2=1.73$, 1 d.f., $0.2>P>0.1$).

Within the region the 0-frequencies are uniform, and most of the series are around or above 63 per cent. The town of Lund shows the highest value, 65.7 per cent. The high values in Halland and Kristianstad counties may in part depend on technical serological errors.

ii. *The blood donor material*

Samples have been collected from Göteborg and Kungälv. The series from Göteborg, however, does not show satisfactory agreement with the expected frequencies, as it contains a significant excess of AB-individuals. The results of the blood donor campaign in the county of Malmöhus have been published by

WILLERT and WINBLAD (1953), and Dr. GRUBB has communicated unpublished data for Kristianstad county.

The AB0-system

Because of an excess of AB's in the Göteborg and Kungälv samples, the consistency of the total material is unsatisfactory. In this material, also, the A-frequencies are below 30 per cent. Malmöhus county's A+AB frequency is significantly lower than that for the rest of the material ($\chi^2=10.06$, 1 d.f., $0.01>P>0.001$).

The B-frequencies are around 7.5 per cent. The lower frequency in Kungälv does not differ significantly from that of the rest of the material ($\chi^2=4.20$, 1 d.f., $0.05>P>0.02$).

Except in the series from Göteborg, the 0-frequencies are above 63 per cent. A significant difference exists between the counties of Malmöhus and Kristianstad ($\chi^2=7.61$, 1 d.f., $0.01>P>0.001$). The result agrees with that from the conscript material, and also supports LUNDMAN's anthropometrical classification of Scania. The western part of Scania, where A-frequencies are low and O-frequencies high, belongs to the area of the southwest Scandinavian ethnical stock.

TABLE 87. *AB0 groups and gene frequencies.*

(Blood donor material)

Subregions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
Göteborg	3.651	763	412	3.146	7.972	8.055	29.8	7.6	62.6	100.42
Kungälv	294	45	31	280	650	3.82	29.2	6.0	64.8	100.88
Malmöhus county	2.430	590	247	2.401	5.668	1.44	27.4	7.7	64.9	100.20
Kristianstad „	2.107	460	185	1.802	4.554	1.20	29.6	7.4	63.0	99.79
Total	8.482	1.858	875	7.629	18.844	4.12	29.0	7.5	63.5	100.19

The Rh-system

No significant heterogeneity exists for the frequency of D-negative individuals within the whole material ($\chi^2=6.80$, 3 d.f., $0.1>P>0.05$).

TABLE 88. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*

(Blood donor material)

Subregions	D+	%	D−	%	n	D-gene	d-gene
1	6.612	82.9	1.360	17.1	7.972	58.7	41.3
2	553	85.1	97	14.9	650	61.4	38.6
3	4.709	83.1	959	16.9	5.668	58.9	41.1
4	3.728	81.9	826	18.1	4.554	57.4	42.6
Total	15.602	82.80	3.242	17.20	18.844	58.53	41.47

In Kungälv the frequency is somewhat lower than in the other samples, but the difference is not significant ($\chi^2=4.35$, 1 d.f., $0.05>P>0.02$).

Frequencies of D-negatives are relatively high within the area.

iii. *The paternity material*

From this area data have been obtained for 1,726 individuals (1,458 for the Rh-system). The 10 original regions have been fused into 6 samples.

The A_1A_2B0-system

No significant heterogeneity exists for the frequency of A+AB within the total material ($\chi^2=5.63$, 5 d.f., $0.5>P>0.3$). As in the data for conscripts and blood donors, the A-frequency for the total material is about 29 per cent. In southwestern Scania, i.e. subregions 6, 8, 9, and 10, the A-frequencies are also lower in this material. The difference from the other regions is, however, not significant ($\chi^2=3.55$, 1 d.f., $0.1>P>0.05$).

No significant heterogeneity exists for the frequency of A_2+A_2B within the total material ($\chi^2=2.57$, 5 d.f., $0.8>P>0.7$). In subregions 1 and 2, farthest north, the A_2-frequency is about 12 per cent. The difference for A_2+A_2B between subregion 2 and the rest of the material is significant ($\chi^2=6.45$, 1 d.f., $0.02>P>0.01$). The high A_2-frequency in Bohuslän points to an Early European influence (cf. BOYD, 1950).

No significant heterogeneity exists for the frequency of B+AB ($\chi^2=7.65$, 5 d.f., $0.5>P>0.3$). Halland also shows the lowest B-frequency in this material. The B-frequency is highest in northwestern Scania. The difference between subregion 4 and subregions 5 and 6 gives $\chi^2=5.10$, 1 d.f., $0.05>P>0.02$.

No significant difference exists for the 0-group ($\chi^2=9.05$, 5 d.f., $0.2>P>0.1$). The 0-frequencies are highest in Halland and southern Scania, lowest in subregions 5 and 6.

TABLE 89. *A_1A_2B0 groups and gene frequencies.*

Subregions	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	P_1	P_2	q	r	p+q+r
1, 2	60	20	20	3	0	51	154	6.00	23.4	9.2	7.8	59.6	97.20
3	124	38	35	13	6	147	363	0.66	21.0	8.1	7.7	63.2	100.56
4	55	17	11	3	1	66	153	0.16	21.2	7.9	5.1	65.8	99.81
5, 6	100	32	32	11	6	97	278	0.24	22.5	9.3	9.2	59.0	100.19
7	60	21	23	6	2	73	185	0.19	19.8	8.2	8.8	63.2	99.54
8, 9, 10	202	51	64	18	4	254	593	0.27	20.7	6.1	7.6	65.6	99.74
Total	601	179	185	54	19	688	1.726	0.40	21.2	7.7	7.8	63.3	99.80

The Rh-system

For the different Rh subgroups no certain differences could be established between regions. Here the groups CDE and DE have relatively low frequencies

TABLE 90. *Rh groups.*

Sub-regions	CD	CDE	DE	D	C	E	Rh-	n
1, 2	69	20	15	1	2	2	20	129
%	53.4	15.5	11.6	0.8	1.6	1.6	15.5	100
3	158	36	45	4	5	2	49	299
%	52.8	12.0	15.1	1.3	1.7	0.7	16.4	100
4	62	16	21	2	1	0	22	124
%	50.1	12.9	16.9	1.6	0.8	0	17.7	100
5, 6	110	44	28	1	3	0	45	231
%	47.7	19.0	12.1	0.4	1.3	0	19.5	100
7	85	19	18	1	2	1	19	145
%	58.6	13.1	12.4	0.7	1.4	0.7	13.1	100
8, 9, 10	270	82	63	7	6	1	101	530
%	50.9	15.5	11.9	1.3	1.1	0.2	19.1	100
Total	754	217	190	16	19	6	256	1.458
%	51.72	14.88	13.03	1.10	1.30	0.41	17.56	100

(below the Swedish average). In a sample from the national population the two groups had frequencies of 15.60 and 15.52 per cent, respectively (JONSSON, 1950). In an English material by RACE et al. (1948) the corresponding frequencies were 13.75 and 13.95 per cent. The frequencies in our southwest Swedish area thus resemble those of England.

The frequencies of D-negative individuals are high in the area as a whole. For this region the frequency for D-negative individuals is about 18—19 per cent. A lower frequency is observed only in subregion 7. A comparison between subregion 7 and the other subregions gives $\chi^2=0.86$, 1 d.f., $0.5>P>0.3$. In subregion 5 (n=58), 34.5 per cent of D-negative individuals is observed.

TABLE 91. *Frequencies of the Rh genes.*

Subregions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
1, 2	56.8	43.2	45.7	54.3	15.5	84.5	129
3	56.6	43.4	42.1	57.9	15.0	85.0	299
4	57.0	43.0	39.8	60.2	16.3	83.7	124
5, 6	54.4	45.6	43.4	56.6	17.1	82.9	231
7	61.0	39.0	48.0	52.0	14.1	85.9	145
8, 9. 10	54.8	45.2	43.0	57.0	14.9	85.1	530
Total	56.11	43.89	43.34	56.66	15.33	84.67	1.458

The MN-system

The consistency of the material is not satisfactory for subregion 4.

The M-frequency for the entire area is relatively low, 54.7 per cent. In subregions 1 and 2 the M-frequency is only 48.4 per cent. A comparison between regions 1 and 2 and regions 3 and 4 gave $\chi^2=5.24$, 1 d.f., $0.05>P>0.02$. Values as low as 48 per cent have previously except for the Lapps been found in Europe only in Spain. They have also been found among the Berbers in North Africa. The low M-frequencies in southwestern Sweden and especially in Bohuslän may be considered indicative of a west-European influence.

TABLE 92. *MN groups and gene frequencies.*

Subregions	MM	MN	NN	n	χ^2	M-gene	N-gene
1, 2	39	71	44	154	0.91	48.4	51.6
3	114	173	76	363	3.46	55.2	44.8
4	42	91	20	153	7.05	57.2	42.8
5, 6	76	150	52	278	2.15	54.3	45.7
7	48	93	44	185	0.01	51.1	48.9
8, 9, 10	187	298	108	593	0.32	56.7	43.3
Total	506	876	344	1.726	0.50	54.70	45.30

The P-system

The P-gene frequency is high in subregions 1 and 2, which points to an influence from southwestern Europe (cf. the M- and A_2-frequencies). The difference for P-negative individuals between subregions 1 and 2 and the rest of the area is, however, not significant ($\chi^2=2.99$, 1 d.f., $0.1>P>0.05$).

TABLE 93. *P groups and gene frequencies.*

Subregions	P+	%	P−	%	n	P-gene	p-gene
1, 2	133	86.4	21	13.6	154	63.1	36.9
3	298	82.1	65	17.9	363	57.7	42.3
4	122	79.7	31	20.3	153	54.9	45.1
5, 6	233	83.8	45	16.2	278	59.8	40.2
7	150	81.1	35	18.9	185	56.5	43.5
8, 9, 10	468	78.9	125	21.1	593	54.0	46.0
Total	1.404	81.35	322	18.65	1.726	56.81	43.19

iv. *Summary*

The A-frequencies are lowest in southwestern Scania. The A_2-frequencies are highest in Bohuslän. The B-frequencies show no significant variation. The 0-frequencies are above 63 per cent, and highest in southwestern Scania. The

frequencies of D-negatives are relatively high, and show no significant variation. The M-frequencies are lowest in Bohuslän. The frequencies of the genes C, E, and P show no significant variation.

11. Main region XI. Gotland

This island lies almost in mid-Baltic at a distance of about 100 kms. from the Swedish coast. It is about 150 kms. from the Baltic provinces, about 220 kms. from East Germany and Poland. Gotland may be described as a uniform limestone plateau covered by a thin layer of loose soil. Most of the island is less than 30 ms. above sea-level.

a) EARLIER ANTHROPOMETRICAL INVESTIGATIONS

The average stature on Gotland is about 175 cms., a fact which places the island among Sweden's highest stature regions. In 1898 and 1926 the stature was 172.7 and 173.6 cms., respectively, both figures considerably higher than the Swedish average. The cephalic index lies between 78 and 79, similar to that of southern Sweden or the Baltic provinces rather than central Sweden. Hair color is very light, resembling that in southeastern Sweden. From the anthropogeographical point of view, LUNDMAN (1946) places Gotland in the irregular southeast Swedish "mosaic" group. Gotland is said to have connections with the west Finnish population.

b) SEROLOGICAL INVESTIGATIONS

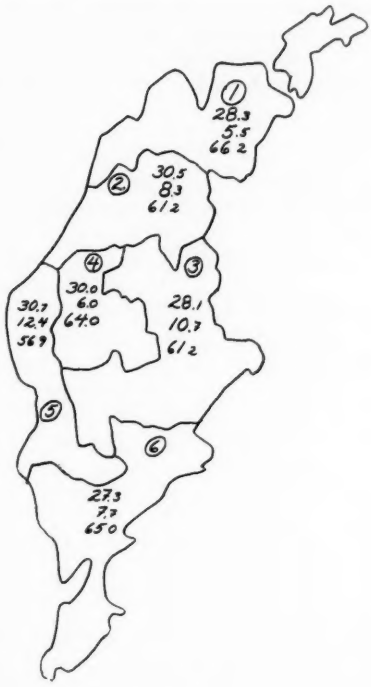
i. *The conscript material*

Material was obtained for 1,442 conscripts born on Gotland, and has been distributed over six regions. The frequencies are seen in Table 95, which also contains information about the association between the subregions for the blood donor material and those for this classification.

TABLE 95. *ABO groups and gene frequencies.*

(Conscript material)

Sub-regions	Corresponding subregions in the blood donor material	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	1, 2	68	11	5	66	150	0.03	28.3	5.5	66.2	100.14
2	3, 4	174	43	16	136	369	0.67	30.5	8.3	61.2	99.40
3	5, 7, 9	117	44	9	93	263	**4.72**	28.1	10.7	61.2	97.95
4	6, 8, 13	75	11	8	68	162	1.14	30.0	6.0	64.0	100.98
5	10, 14	86	33	10	57	186	2.03	30.7	12.4	56.9	98.15
6	11, 12	134	33	13	132	312	0.0001	27.3	7.7	65.0	100.01
Total		654	175	61	552	1.442	2.04	29.2	8.5	62.3	99.48



Map 24. Frequencies of the A, B and 0 genes. (Conscript material.)

The data from one of the constituent areas show a significant inconsistency. No significant heterogeneity exists for the frequency of A+AB ($\chi^2=1.25$, 5 d.f., $0.95>P>0.90$). The A-frequencies above 30 per cent are concentrated in three subregions in the west (Map 24). The east-Swedish mainland shows similar frequencies. The B-frequencies are relatively high, in subregions 3 and 5 above 10 per cent. This circumstance may be interpreted as the result of an eastern influence. The frequencies are lower in subregion 4, which is surrounded by subregions 2, 3, and 5 with higher frequencies. χ^2 for the difference between subregion 4 and subregions 2, 3, and 5 was 7.47, 1 d.f., $0.01>>P>0.001$.

No significant heterogeneity exists for the 0-group within the total material ($\chi^2=11.35$, 5 d.f., $0.1>P>0.05$). (See Map 24.)

ii. *The blood donor material*

The Red Cross district of Gotland has provided the data for my statistical analysis. The determinations of the blood groups were made under the supervision of Dr. O. E. ODÉN at the Visby hospital. Gotland consists of a great number of very small parishes; almost all are represented by samples. The

total number of individuals examined is 2,170, corresponding to 3.7 per cent of the island's total population.

A fusion of the primary subregions led to a final classification into 14 subregions for the AB0-data and 13 subregions for the Rh-data.

The AB0-system

A significant heterogeneity exists for the frequency of A+AB ($\chi^2=40.41$, 13 d.f., $P>0.001$). The frequencies are shown in Table 96 and Map 25.

TABLE 96. *AB0 groups and gene frequencies.*
(Blood donor material)

Sub-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
1	36	8	2	36	82	0.05	27.6	6.3	66.1	100.28
2	56	19	11	57	143	1.09	26.9	11.1	62.0	101.39
3	188	35	20	102	345	0.11	37.1	8.3	54.6	99.69
4	66	11	5	51	133	0.01	31.8	6.2	62.0	99.88
5	42	12	8	50	112	1.88	25.3	9.3	65.4	101.77
6	45	9	6	51	111	1.26	26.4	6.9	66.7	101.26
7	49	33	7	49	138	1.32	23.1	15.9	61.0	98.25
8	59	10	6	51	126	0.32	30.4	6.5	63.1	100.64
9	59	17	5	52	133	0.53	28.1	8.6	63.3	99.11
10	92	28	9	107	236	0.03	24.4	8.2	67.4	99.86
11	86	16	2	83	187	2.52	27.4	5.0	67.6	98.82
12	95	24	6	68	193	0.22	31.1	8.2	60.7	98.42
13	55	2	6	41	104	**5.20**	35.3	3.9	60.8	102.43
14	66	11	9	41	127	0.52	35.9	8.1	56.0	101.06
Total	994	235	102	839	2.170	0.053	29.6	8.1	62.3	99.93

The maximum value for gene A is rather high, 37.1 per cent. A narrow tract of lower A-frequencies seems to traverse the island (subregions 5, 6, 7, and 10), and a similar small area is found in the far north. Since low A-frequencies are an indication of west-European influence, it is possible that these areas have received a west-European ethnical element related to the population of south-western Sweden. The comparative isolation of the island population has probably contributed to the preservation of ancient west-European traits.

The frequency of B+AB shows a significant heterogeneity ($\chi^2=36.54$, 13 d.f., $0.001>P$).

The maximum value, 15.9 per cent, is found farthest east (in subregion 7). High values are found also in subregions 2 and 5. The lowest values are found mainly in the central part of the island, viz. in subregions 6, 8, and 13. This agrees with the result from the conscript material.

Significant heterogeneity exists for the 0-group ($\chi^2=28.01$, 13 d.f., $0.01>>P>0.001$). The maximum value is 67.6 per cent. Frequencies exceeding 65 per cent are found in five regions.

Map 25. Frequencies of the A, B and 0 genes. (Blood donor material.)

The Rh-system

The frequencies of D-negatives in the 13 different subregions are shown in Table 97.

No significant heterogeneity is found for the frequency of D-negative individuals ($\chi^2=16.10$, 12 d.f., $0.2>P>0.1$). Subregions 4, 8, 9, 10, and 12 form a tract with lower frequencies of D-negative individuals obliquely across the island (see Map 26). Here the frequency of D-negative individuals averaged 11.4 per cent. A comparison between the above-mentioned subregions and the rest of the area gives $\chi^2=8.47$, 1 d.f., $0.01>P>0.001$. The frequency of D-negative individuals was highest where the B-frequency was highest, i.e., in the east and the north.

iii. *The paternity material*

Data for 186 individuals have been obtained (167 for the Rh-system). The material has not been regionally classified.

The A_1A_2B0-system

The total figures for Gotland agree well with those obtained from the other two sets of data.

TABLE 97. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d.*
(Blood donor material)

Sub-regions	D+	%	D−	%	n	D-gene	d-gene
1	139	86.9	21	13.1	160	63.8	36.2
2	161	81.3	37	18.7	198	56.8	43.2
3	293	84.9	52	15.1	345	61.1	38.9
4	97	87.4	14	12.6	111	64.5	35.5
5	95	84.8	17	15.2	112	61.0	39.0
6	109	79.0	29	21.0	138	54.2	45.8
7	102	81.0	24	19.0	126	56.4	43.6
8	120	90.2	13	9.8	133	68.7	31.3
9	211	89.4	25	10.6	236	67.4	32.6
10	91	87.5	13	12.5	104	64.6	35.4
11	106	83.5	21	16.5	127	59.4	40.6
12	164	87.7	23	12.3	187	64.9	35.1
13	166	86.0	27	14.0	193	62.6	37.4
Total	1.854	85.44	316	14.56	2,170	61.84	38.16

Map 26. Frequencies of Rh-negative individuals. (Blood donor material.)

TABLE 98.

A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
65	21	20	8	1	71	186	0.004	22.0	8.0	8.1	61.9	99.94

The A_2-frequency does not differ from values on the Swedish mainland. The Latvians differ from the Finns by their low A_2-frequencies. If the eastern Gotland element is derived from the Baltic provinces, high B-frequencies might be expected to be combined with low A_2-frequencies. For a final decision as to whether the high B-frequencies on Gotland are of south Baltic or Finnish origin, more data on the blood groups (especially MN and A_2) are needed. A better knowledge of blood group conditions in the Baltic countries is also desirable.

The Rh-system

Table 99 shows a relatively low frequency of D-negative individuals. For the blood donor material, a low frequency of D-negative individuals was found in the western and central parts of the island.

TABLE 99.

	CD	CDE	DE	D	C	E	Rh-	n
n	94	26	25	2	0	0	20	167
%	56.29	15.57	14.97	1.20	0	0	11.97	100

The frequency of gene C is high, suggesting an eastern element.

TABLE 100.

D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
65.40	34.60	46.95	53.05	16.55	83.45	167

The MN-system

The consistency of the material is satisfactory ($\chi^2=0.46$, 1 d.f., $0.5>P>0.3$). Gotland (cf. Table 101) does not differ significantly from the Swedish mainland or from Estonia, according to a series by ROOKS (quoted by BOYD, 1939), which shows a gene M-frequency of 59.0 per cent (n=310).

TABLE 101.

MM	MN	NN	n	M-gene	N-gene
57	96	33	186	56.45	43.55

The P-system

No certain difference is found between Gotland and the mainland.

TABLE 102.

P+	%	P−	%	n	P-gene	p-gene
147	79.03	39	20.97	186	54.20	45.80

iv. *Summary*

The A-frequencies are lowest in a tract traversing the central parts. The B-frequencies are highest in the east and lowest in the central parts. The frequency of D-negative individuals is highest in the east, and lowest in the central parts. With regard to the frequencies for the genes C, E, M, and P, Gotland and the mainland appear to be similar.

C. GENERAL SECTION

1. The AB0-system

a) THE MATERIAL

As the different materials have been tested by different methods, it is convenient to treat them separately in this section. In Table 103 data for the conscript material are given for the eleven main regions. The total number of tested individuals is 131,659.

Five of the main constituent regions show a significant inconsistency. χ^2 for the total data shows a large deficiency with regard to the AB group. All significantly inconsistent areas have the same deficiency for AB individuals — a common feature in large samples (cf. FRASER ROBERTS, 1953, DOBSON and IKIN, 1946).

For the 73,581 blood donors three of the main regions have significant deviations from the expected values. The uncorrected gene sum is higher than 1. The greatest deviation is shown by Main Region VII, Dalecarlia. The discrepancy here is, in reality, somewhat greater; but as previously mentioned, some parishes with extremely abnormal frequency distributions have been discarded.

The total data for the blood donor material show a highly significant inconsistency with the expected values. The discrepancies are of a rather unusual type, as with AB- and 0-excess and A- and B-deficiency. The calculated excess of AB-individuals was 225, and of 0-individuals, 167. A serological misclassification of A and B owing, for instance, to

TABLE 103. *AB0 groups and gene frequencies of the main regions.*
(Conscript material)

Main-regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
I	3.972	806	361	3.024	8.163	1.96	29.5	7.8	62.7	99.79
%	48.66	9.87	4.42	37.05	100					
II	3.622	1.054	306	3.329	8.311	**27.59**	27.5	8.6	63.9	99.23
%	43.58	12.68	3.68	40.06	100					
III	2.594	618	259	2.715	6.186	1.73	26.6	7.3	66.1	100.20
%	41.93	9.99	4.19	43.89	100					
IV	1.901	367	167	1.530	3.965	0.15	30.8	7.0	62.2	99.92
%	47.94	9.26	4.21	38.59	100					
V	2.506	476	203	1.828	5.013	**4.03**	32.3	7.0	60.7	99.62
%	49.99	9.50	4.05	36.47	100					
VI	3.503	918	355	3.176	7.952	1.78	28.3	8.3	63.4	99.80
%	44.05	11.54	4.46	39.94	100					
VII	11.702	2.588	1.139	8.691	24.120	**11.39**	31.7	8.1	60.2	99.69
%	48.52	10.73	4.72	36.03	100					
VIII	6.581	1.424	589	5.382	13.976	**4.89**	30.2	7.5	62.3	99.75
%	47.09	10.19	4.21	38.51	100					
IX	9.487	1.766	906	7.109	19.268	0.38	32.1	7.2	60.7	100.06
%	49.24	9.17	4.70	36.89	100					
X	15.270	3.330	1.294	13.369	33.263	**12.99**	29.2	7.2	63.6	99.75
%	45.91	10.01	3.89	40.19	100					
XI	654	175	61	552	1.442	2.04	29.2	8.5	62.3	99.48
%	45.35	12.14	4.23	38.28	100					
Total	61.792	13.522	5.640	50.705	131.659	**37.958**	30.18	7.57	62.25	99.77
%	46.93	10.27	4.29	38.51	100					

weak sera, cannot at the same time produce an AB excess. Perhaps, in the course of a blood donor campaign, some sort of selectivity occurs. A man who remembers his blood group, having been typed during military service, may also recall that 0 is a "good group" and AB uncommon. Hence it may be suspected that such individuals will be more enthusiastic to enrol themselves as blood donors. A division by sex of the blood donor material from Jämtland indicates the existence of such a selection. The frequency of the 0-group was 38.7 per cent for men and 37.7 per cent for women. The difference, while not significant, is in the expected direction — that is, higher 0 among men.

TABLE 104. *AB0 groups and gene frequencies of the main regions.*
(Blood donor material)

Main regions	A	B	AB	0	n	χ^2	p	q	r	p+q+r
I	805	196	127	726	1.854	1.07	29.4	8.3	62.3	100.33
%	43.42	10.57	6.85	39.16	100					
II	868	222	103	787	1.980	0.33	28.5	8.6	62.9	100.25
%	43.84	11.21	5.20	39.75	100					
III	2.831	647	279	2.715	6.472	0.71	27.9	7.4	64.7	100.13
%	43.74	10.00	4.31	41.95	100					
IV	3.198	699	310	2.568	6.775	0.52	30.6	7.8	61.6	99.88
%	47.20	10.32	4.58	37.90	100					
V	3.145	641	358	2.412	6.556	3.16	31.7	7.9	60.4	100.31
%	47.97	9.78	5.46	36.79	100					
VI	4.461	1.111	570	3.824	9.966	**7.88**	29.6	8.8	61.6	100.40
%	44.76	11.15	5.72	38.37	100					
VII	3.149	672	364	2.358	6.543	1.65	31.9	8.2	59.9	100.23
%	48.13	10.27	5.56	36.04	100					
VIII	2.351	556	286	1.802	4.995	0.74	31.3	8.8	59.9	100.18
%	47.07	11.13	5.73	36.07	100					
IX	3.515	683	366	2.862	7.426	**4.05**	30.9	7.3	61.8	100.31
%	47.33	9.20	4.93	38.54	100					
X	8.482	1.858	875	7.629	18.844	**4.12**	29.0	7.5	63.5	100.19
%	45.01	9.86	4.64	40.49	100					
XI	994	235	102	839	2.170	0.05	29.6	8.1	62.3	99.93
%	45.80	10.83	4.71	38.66	100					
Total	33.799	7.520	3.740	28.522	73.581	**11.448**	29.97	7.96	62.07	100.24
%	45.94	10.22	5.08	38.76	100					

The paternity material shows the best agreement with the expected frequencies. This is to be expected, as this material, from the aspect of serological technique, is far superior to the two previous sets of data. Main Region VII alone shows a significant inconsistency.

It must not be concluded from this that the conscript data are not useful in population genetics. ROSIN (1956), e.g., has published an extensive and valuable investigation dealing only with AB0-data from Swiss conscripts. Most of the errors come from the misclassification of AB-individuals. A_2B is often classified as B. In this way the A-frequency will be lowered, and the 0-frequency raised. Thus, in the first place,

TABLE 105. *A_1A_2B0 groups and gene frequencies of the main regions.*

(Paternity material)

Main regions		A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
I		168	111	61	16	13	209	578	0.05	17.5	14.2	8.1	60.2	99.87
	%	29.07	19.20	10.55	2.77	2.25	36.16	100						
II		118	73	38	12	6	157	404	0.01	17.7	12.9	7.2	62.2	100.07
	%	29.21	18.07	9.41	2.97	1.49	38.86	100						
III		130	50	39	11	5	163	398	0.004	19.6	9.2	7.2	64.0	99.96
	%	32.66	12.56	9.80	2.76	1.26	40.95	100						
IV		135	66	42	10	8	172	433	0.02	18.4	11.3	7.2	63.1	99.92
	%	31.18	15.24	9.70	2.31	1.85	39.72	100						
V		198	57	39	10	10	174	488	0.03	24.3	9.7	6.3	59.7	99.89
	%	40.57	11.68	7.99	2.05	2.05	35.66	100						
VI		148	34	38	22	5	143	390	2.32	24.8	6.9	8.6	59.7	101.14
	%	37.95	8.72	9.74	5.64	1.28	36.67	100						
VII		1.153	311	303	132	47	1.189	3.135	**5.61**	23.1	7.8	8.0	61.1	100.59
	%	36.78	9.92	9.67	4.21	1.50	37.93	100						
VIII		528	134	156	48	12	549	1.427	1.26	22.8	6.9	7.9	62.4	99.60
	%	37.00	9.39	10.93	3.36	0.84	38.47	100						
IX		521	138	119	38	17	459	1.292	0.67	24.7	8.4	7.0	59.9	99.69
	%	40.33	10.68	9.21	2.94	1.32	35.53	100						
X		601	179	185	54	19	688	1.726	0.40	21.2	7.7	7.8	63.3	99.80
	%	34.82	10.37	10.72	3.13	1.10	39.86	100						
XI		65	21	20	8	1	71	186	0.004	22.0	8.0	8.1	61.9	99.94
	%	34.95	11.29	10.75	4.30	0.54	38.17	100						
Total		3.765	1.174	1.040	361	143	3.974	10.457	0.277	22.17	8.56	7.68	61.59	100.07
	%	36.00	11.23	9.95	3.45	1.37	38.00	100						

unusually high 0-frequencies should be doubted. It has been found, however, that in the area of Sweden where the highest 0-frequencies occur (main region III, Västernorrland county) the data yield high 0-frequencies and likewise a good consistency with the expected frequencies. Further, when using blood group determinations for population genetics, the gene frequency analysis gives a possibility of measuring discrepancies in the composition of the material and to eliminate too inconsistent series.

b) VARIATION

The question must be put as to whether there is a significant degree of heterogeneity for the different genes between the eleven main regions. It must be remembered that the division into eleven main regions was merely a practical convenience for the detailed presentation of the data. Furthermore, a significant heterogeneity has been observed within many of the main regions; hence, the division into main regions does not give an ideal description of the heterogeneity within the country. If this arbitrary division gives a significant heterogeneity, an analysis based on an *a posteriori* division (obtained by adding subregions) will consequently reveal a still higher heterogeneity. In analyzing the heterogeneity, the variation of the frequency A+AB is assumed to be a measure of the variation of the A-gene, A_2+A_2B of the A_2-gene, B+AB of the B-gene, and 0 of the 0-gene. The results (χ^2-values and significance levels) are shown in Table 106.

The A-, B-, and 0-genes reveal a highly significant heterogeneity in the conscript and blood donor materials. In the paternity material the A_2-gene shows a highly significant heterogeneity.

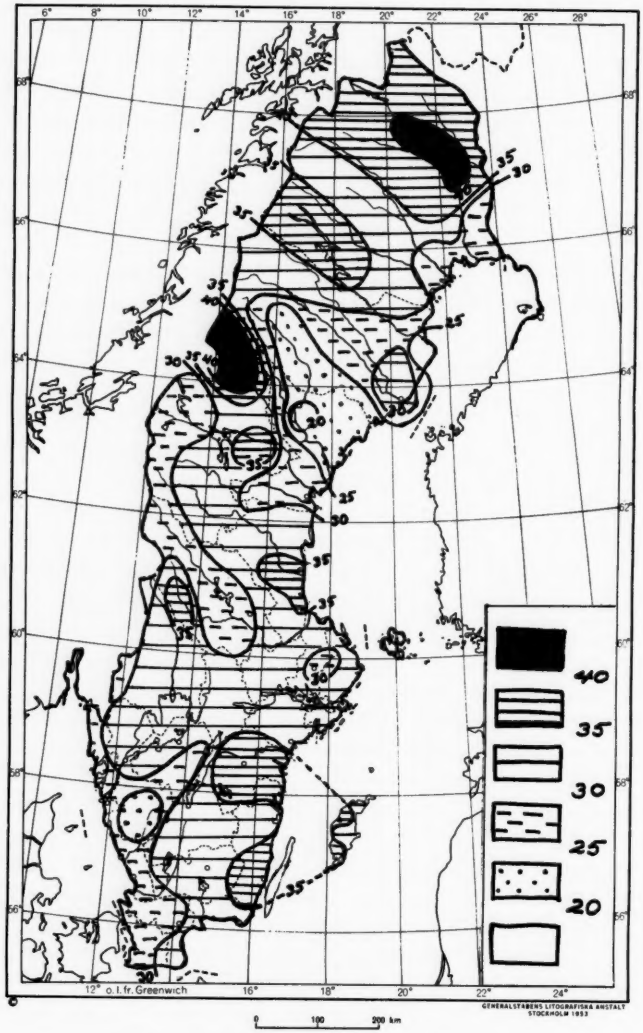
c) THE MAPS

i. *Total A-gene*

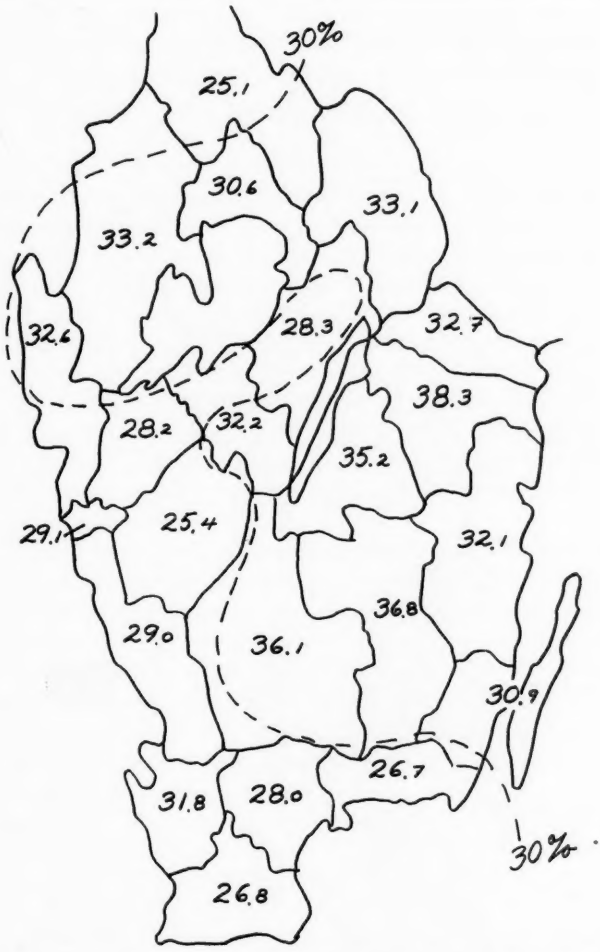
Map 27 shows two high frequency areas for A — one in northern Norrbotten and the other in northern Jämtland. The lowest frequencies (less than 25 per cent) are also found in two different areas — one in Ångermanland and the other in Västergötland. Southwest Sweden and the western parts of Dalecarlia and Jämtland have frequencies below 30 per cent. Low A-frequencies indicating a west-European element have thus been found in southwestern and northeastern Sweden. This result was somewhat surprising, especially for northern Sweden. Southeastern Sweden, the Mälar district and a region stretching from central

TABLE 106. *Variations of the AB0 groups between the main regions.*

Material	A + AB		$A_2 + A_2B$		B + AB		0		DF
	χ^2	P	χ^2	P	χ^2	P	χ^2	P	
The conscript material	231.291	$P < 0.001$	—	—	72.600	$P < 0.001$	181.627	$P < 0.001$	10
The blood donor material	81.683	$P < 0.001$	—	-	64.364	$P < 0.001$	105.408	$P < 0.001$	10
The paternity material	17.866	$0.1 > P > 0.05$	83.525	$P < 0.001$	7.567	$0.7 > P > 0.5$	10.615	$0.5 > P > 0.3$	10

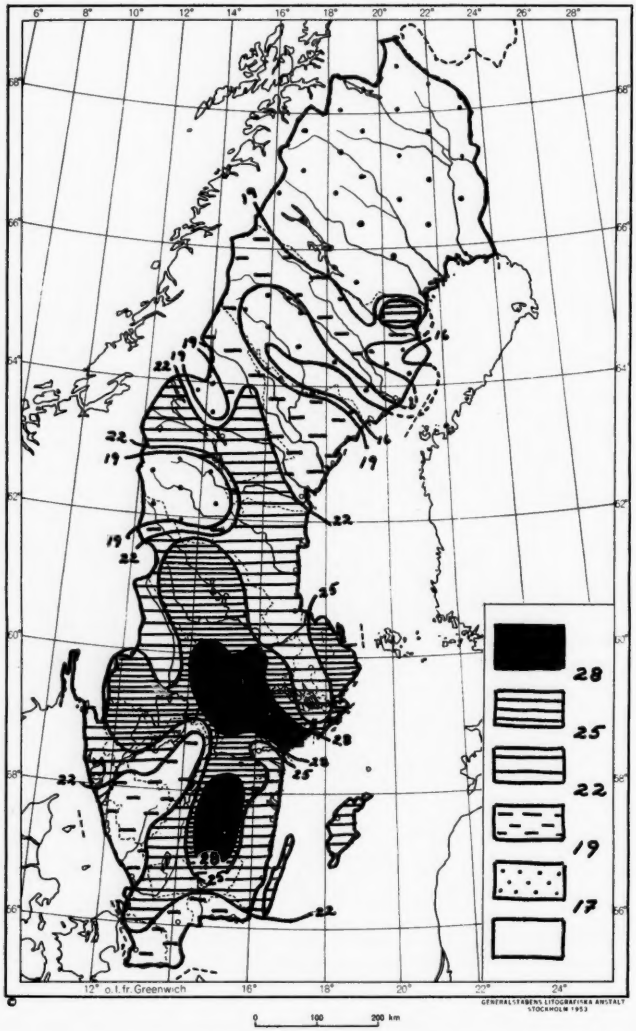


Map 27. Distribution of the A gene in Sweden.



Map 28. The frequency of the A gene in South Sweden illustrated by the paternity material only. Approximate isogene for 30 per cent drawn.

Sweden up through Jämtland have frequencies above 30 per cent. The very high A-frequencies in Norrbotten and Jämtland probably depend on a Lappish influence. The difference between the western and eastern parts of south Sweden is expressed in a similar way by the three different sets of data. Map 28 shows the variation of the A-frequencies in



Map 29. Distribution of the A_1 gene in Sweden.

south Sweden illustrated only by the paternity material. The same result as for the combined material is obtained; viz., the eastern parts have frequencies always exceeding 30 per cent, and the lowest figures are found in southern Västergötland. (See Map 28.)

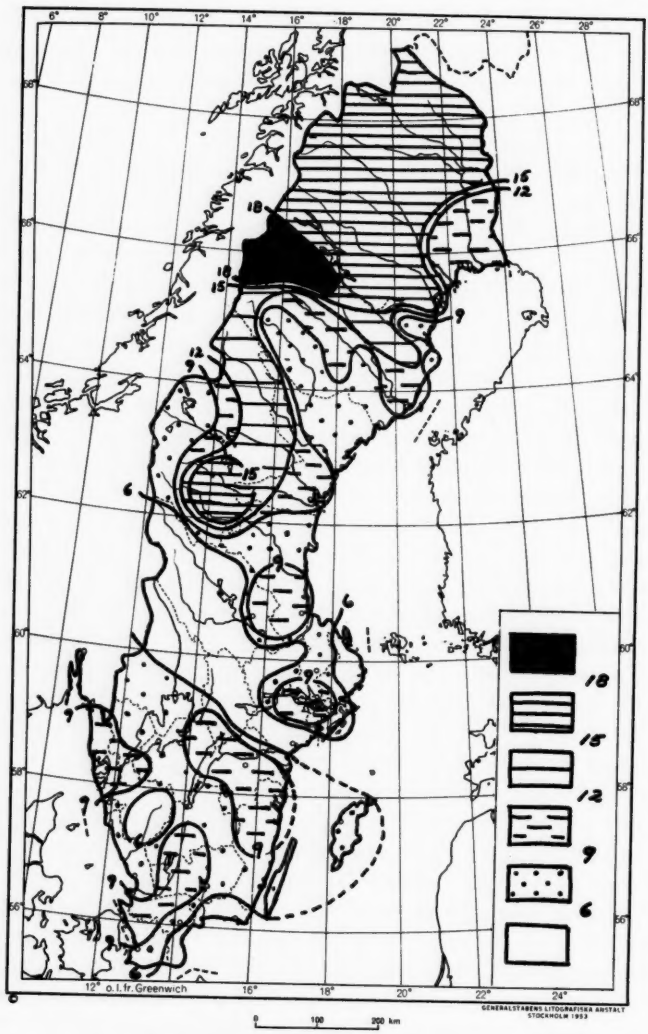
ii. *A_1- and A_2-genes*

The frequency of the "specifically Lappish" A_2-gene showed a significant heterogeneity within the country which is one of the most interesting results of this investigation. Because of the somewhat raised A_2-frequency in Finland and Scandinavia, MOURANT (1954) assumed a continuous diffusion of A_2-genes in past times into populations bordering to Lapland. He also says: "— but this cannot correspond to a total Lapp component of more than about 10 per cent." If we assume an A_2-frequency of 5 per cent in the surrounding non-Lapp mixed populations and 35 per cent in pure Lapps, a 10 per cent Lapponian introgression would be necessary to achieve a mixed population with about 8 per cent. MOURANT's statement is probably based on a calculation similar to the one outlined above.

In Lapland we find A_2-frequencies above 17 per cent in a relatively large area (see Map 30). The northern part of the coastal area of Norrbotten has significantly lower frequencies than the inland area. In central Sweden we find an area with low frequencies. Eastern Dalecarlia and Gästrikland have relatively high frequencies. There is also a significant rise in the central part of the Mälar area (main region VII). South of the central Swedish low frequency area local rises occur in Östergötland, Västergötland and Småland. All these above-mentioned details of the map are statistically significant.

High A_2-frequencies demonstrate a considerable Lappish component in the population of northern Sweden. This Lappish influence is clearly detectable as far south as Jämtland, and some rises in frequency further south may perhaps be caused by the same influence.

The A_1-gene (Map 29) shows a well defined maximum area in central Sweden. The same path of high frequencies running from the Mälar district up through Jämtland observed for total A-gene is also found on this map. A high A_1-frequency as well as a high B-frequency may be looked upon as an "East criterion". The Latvians have 26 per cent, the eastern Finns 24.2 per cent, and the western Finns 20 per cent of the A_1-gene. The central Swedish area with an A_1-frequency above 28 per cent coincides with the kernel area for the inner-Scandinavian stock (LUNDMAN, 1946). The map shows a tendency toward a spread from



Map 30. Distribution of the A_2 gene in Sweden.

the above-mentioned area northward (Dalecarlia) and southward (Småland).

iii. *The B-gene*

On MOURANT's earlier map 5 per cent intervals have been used for the isogenes. I have used 3 per cent intervals, which give a more detailed description of the variation in Sweden. Relatively high B-frequencies (above 9 per cent) are found in a big continuous area in central Sweden, in the eastern part of Uppland (Roslagen), in central and western Jämtland, in Norrbotten, Västerbotten and finally in eastern Gotland. The B-frequencies in the coastal area from Kalmar in the south to Medelpad in the north are significantly higher than those in the inland.

The lowest frequencies are obtained in northeastern Norrbotten and northern Jämtland. Relatively low frequencies (below 6 per cent) are found also in south Sweden. The detailed extension of the south Swedish area is not very accurate, as in many cases the frequencies are insignificantly below 6 per cent (see Map 31).

Earlier the Gulf of Bothnia and the Baltic have generally been regarded as a marked serological border. West of this border the frequencies should always be lower than 10 per cent. This investigation has shown, however, that considerable areas in north and central Sweden have frequencies above 10 per cent, which indicates an eastern influence. The high frequencies in central and western Jämtland are remarkable in that they are combined with other serological traits indicative of a western influence (e.g., low M and high frequency of Rh-negative individuals).

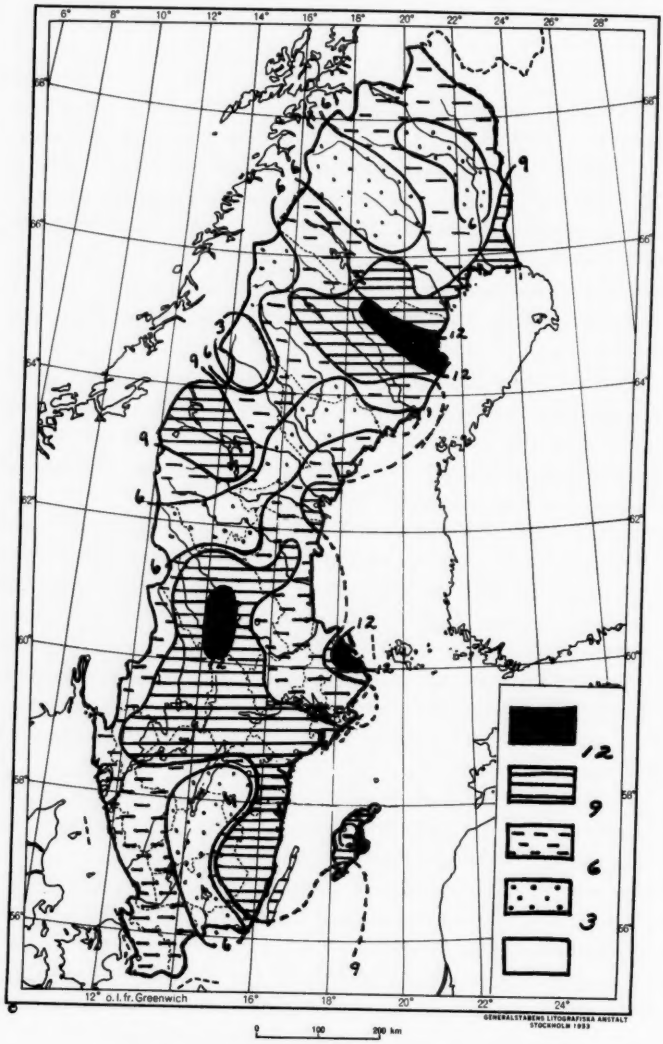
The central Swedish high frequency area for B seems to coincide to a large extent with the high frequency area for A_1. This association is absent in the north Swedish high frequency area for B.

The two main paths of eastern influence (in north and central Sweden) are located adjacent to the most favourable places for sea crossings from the more easterly lands.

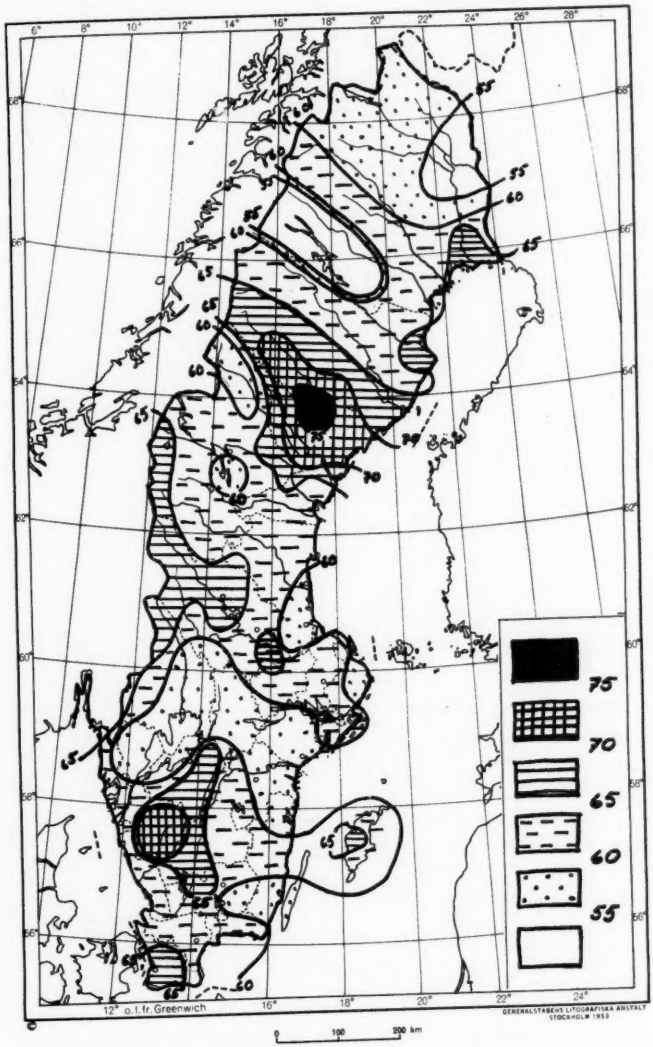
According to the results obtained for the B-gene, the eastern influence in north Sweden should be strongest in the northern part of Västerbotten county and the eastern part of Norrbotten county.

iv. *The 0-gene*

0-frequencies vary considerably in Sweden. The highest values are found in Västergötland and in Ångermanland and southern Västerbot-



Map 31. Distribution of the B gene in Sweden.



Map 32. Distribution of the 0 gene in Sweden.

ten, where frequencies of about 70 per cent cover a relatively large area and values higher than 75 per cent have been found.

These high frequencies are, as previously mentioned, strikingly similar to those of northwest Scotland, Ireland and Iceland. Relatively high 0-frequencies are found also in the north Swedish coastal area, in western Jämtland and Dalecarlia and on Gotland. The lowest frequencies (below 60 per cent) are found in central Sweden (approximately in the same area which showed high A_1- and B-frequency) and in the northern part of Norrbotten county (see Map 32).

The main result for the AB0-system may be expressed in the following way: At least three different population elements may be distinguished.

a) An element with high total A, high A_2 and low B — the Lappish element.
b) An element with high A_1 and high B — the eastern element.
c) An element with low A and high 0 — the west-European element.

2. The Rh-system

a) THE MATERIAL

The frequencies of the Rh groups in the main regions are shown in Tables 107 and 108.

TABLE 107. *Frequencies of D-positive and D-negative individuals and gene frequencies for D and d in the main regions.*
(Blood donor material)

Main regions	D+	%	D−	%	n	D-gene	d-gene
I	1.469	79.23	385	20.77	1.854	54.43	45.57
II	1.678	84.75	302	15.25	1.980	60.94	39.06
III	5.553	85.80	919	14.20	6.472	62.32	37.68
IV	5.717	84.38	1.058	15.62	6.775	60.48	39.52
V	5.625	85.80	931	14.20	6.556	62.32	37.68
VI	8.574	86.03	1.392	13.97	9.966	62.62	37.38
VII	5.487	83.86	1.056	16.14	6.543	59.83	40.17
VIII	4.105	82.18	890	17.82	4.995	57.79	42.21
IX	6.173	83.13	1.253	16.87	7.426	58.93	41.07
X	15.602	82.80	3.242	17.20	18.844	58.53	41.47
XI	1.854	85.44	316	14.56	2.170	61.84	38.16
Total	61.837	84.04	11.744	15.96	73.581	60.05	39.95

TABLE 108. *Rh groups in the main regions.*

Main regions	CD	CDE	DE	D	C	E	CE	Rh-	n
I	257	87	96	4	8	0	0	51	503
%	51.09	17.30	19.09	0.80	1.59	0	0	10.13	100
II	178	70	54	4	3	1	0	49	359
%	49.58	19.50	15.04	1.12	0.83	0.28	0	13.65	100
III	174	46	49	8	4	1	0	46	328
%	53.05	14.03	14.94	2.44	1.22	0.30	0	14.02	100
IV	179	56	60	10	4	0	1	69	379
%	47.23	14.78	15.83	2.64	1.06	0	0.26	18.20	100
V	194	57	83	11	6	1	0	47	399
%	48.62	14.29	20.80	2.76	1.50	0.25	0	11.78	100
VI	156	45	58	3	2	3	0	50	317
%	49.21	14.19	18.30	0.95	0.63	0.95	0	15.77	100
VII	1.287	386	419	34	17	6	0	328	2.477
%	51.96	15.58	16.92	1.37	0.69	0.24	0	13.24	100
VIII	566	165	181	17	9	4	0	158	1.100
%	51.46	15.00	16.45	1.55	0.82	0.36	0	14.36	100
IX	492	146	157	9	13	7	0	177	1.001
%	49.15	14.59	15.68	0.90	1.30	0.70	0	17.68	100
X	754	217	190	16	19	6	0	256	1.458
%	51.72	14.88	13.03	1.10	1.30	0.41	0	17.56	100
XI	94	26	25	2	0	0	0	20	167
%	56.29	15.57	14.97	1.20	0	0	0	11.97	100
Total	4.331	1.301	1.372	118	85	29	1	1.251	8.488
%	51.02	15.33	16.16	1.39	1.00	0.34	0.01	14.74	100

The chromosome frequencies have been calculated according to MOURANT (1954). This method is based on an omission of the rare combinations CDE and CdE and gives a relatively good estimate of the chromosome frequencies in series tested with only three antisera. The calculation is based on a parallel with the AB0-calculation. By grouping the six combinations into three groups of two combinations each, I have used the previously mentioned formula (STEVENS, 1950) to measure the consistency with expected frequencies.

b) VARIATION

The frequencies of the CDe-chromosome vary around 40 per cent and thus do not differ significantly from those in the rest of Europe.

TABLE 109. *Frequencies for the Rh genes in the main regions.*

Main regions	D-gene	d-gene	C-gene	c-gene	E-gene	e-gene	n
I	65.76	34.24	45.21	54.79	20.74	79.26	503
II	61.58	38.42	45.15	54.85	19.26	80.74	359
III	60.56	39.44	43.70	56.30	15.90	84.10	328
IV	55.82	44.18	38.62	61.38	16.85	83.15	379
V	63.22	36.78	40.34	59.66	19.59	80.41	399
VI	58.35	41.65	40.02	59.98	18.41	81.59	317
VII	62.36	37.64	43.65	56.35	17.38	82.62	2.477
VIII	60.58	39.42	42.80	57.20	17.43	82.57	1.100
IX	55.64	44.36	40.87	59.13	16.91	83.09	1.001
X	56.11	43.89	43.34	56.66	15.33	84.67	1.456
XI	65.40	34.60	46.95	53.05	16.55	83.45	167
Total	59.92	40.08	42.88	57.12	17.45	82.55	8.488

The Cde-, cdE-, cde-, and cDe-chromosomes show frequencies similar to other northwest-European populations. The frequencies of the cDE-chromosome are high as compared with other populations.

The result of the heterogeneity analysis is shown in Table 111.

For the whole country there is a significant heterogeneity for the frequencies of D-, E-, and Rh-negatives as well as for the frequency of the DE-group. The frequency of D-negatives shows heterogeneity in both the blood donor and the paternity material. The frequencies of D-negative individuals in each main region are, however, not directly

TABLE 110. *Chromosome frequencies in the main regions.*

Main regions	CDe	Cde	cDE	cdE	cDe	cde	n	χ^2
I	41.34	2.32	20.44	0.00	2.82	33.08	503	2.00
II	43.35	1.16	18.59	0.40	1.40	35.10	359	3.08
III	42.06	1.60	15.50	0.39	3.11	37.34	328	0.012
IV	37.15	1.25	16.76	0.00	2.94	41.90	379	0.76
V	38.68	2.05	19.42	0.36	3.96	35.53	399	1.77
VI	39.39	0.77	17.31	1.16	1.19	40.18	317	0.16
VII	42.89	0.93	17.11	0.33	1.85	36.89	2.477	1.69
VIII	41.71	1.07	16.95	0.47	1.98	37.82	1.100	0.017
IX	39.15	1.54	16.00	0.83	1.04	41.44	1.001	1.14
X	41.38	1.57	14.71	0.49	1.28	40.57	1.458	7.56
XI	47.00	0.00	16.64	0.00	1.69	34.67	167	0.002
Total	41.49	1.29	16.96	0.45	1.76	38.05	8.488	2.59

comparable in the two sets of data, since there is sometimes a difference in the regional representation.

TABLE 111. *Variations between the main regions (Rh groups).*

Heterogeneity for frequency of	χ^2	P	DF
CD	10.023	$0.5 > P > 0.3$	10
CDE	8.067	$0.7 > P > 0.5$	10
DE	23.401	$0.01 > P > 0.001$	10
Rh-neg.	36.943	$P < 0.001$	10
C-neg.	20.047	$0.05 > P > 0.02$	10
D-neg.	61.702	$P < 0{,}001$	10
E-neg.	86.940	$P < 0{,}001$	10
D-neg. (Blood donors)	135.348	$P < 0.001$	10

c) THE MAPS

i. *Chromosomes*

On Map 33 the frequencies of the chromosomes have been mapped.

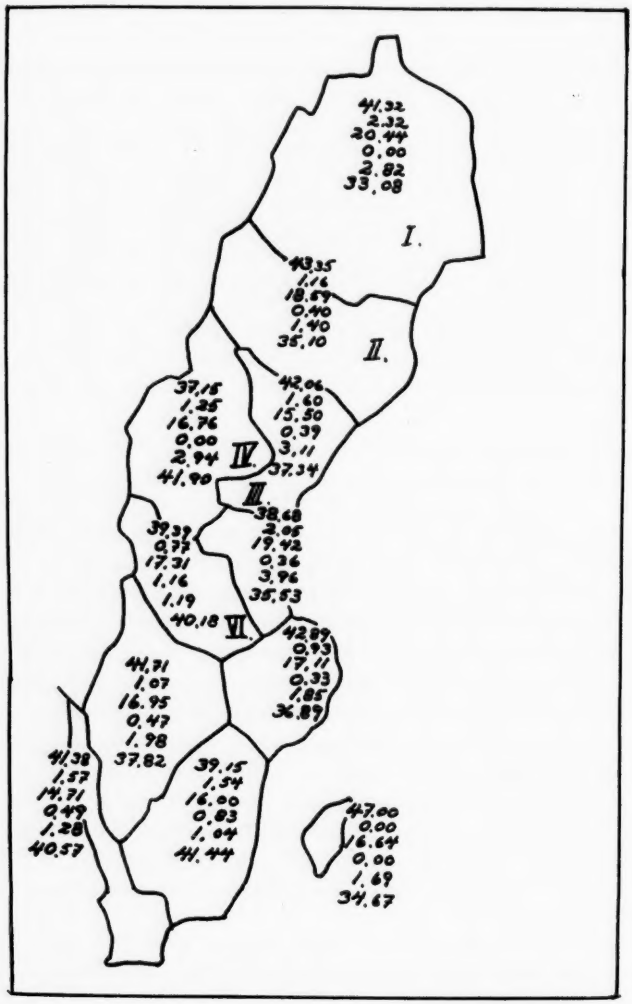
The cDE-frequencies are highest in Norrbotten county, relatively high in Västerbotten county and in central Sweden. The lowest frequencies are found in Västernorrland county and in southwest Sweden.

The frequencies of the cDE-chromosome are low in southern and western Europe and high in parts of Asia and Africa. Populations believed to represent remnants of an Early European population (e.g., the Basques) show very low cDE-frequencies. Norwegian and some Swedish Lapps (ALLISON et al., 1952 and 1956) have been found to have high frequencies approaching "Asiatic" values. The Latvians also have a relatively high frequency. Hypotheses concerning the west-European influence in Sweden based on the AB0-data are supported by the distribution of the cDE-frequencies. Low frequencies were found in Main Regions III and X.

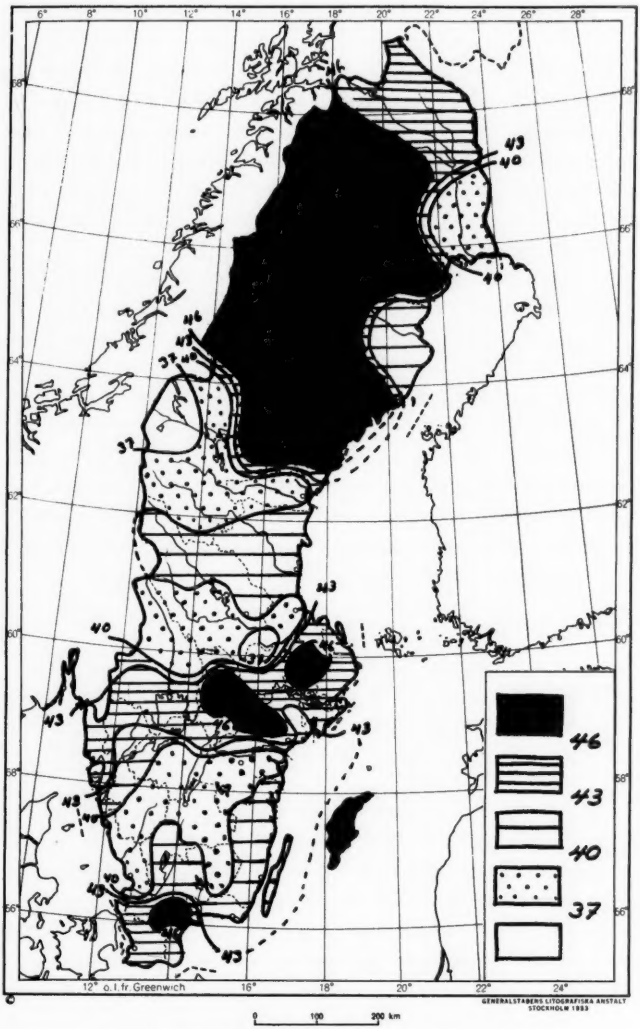
The low cde-frequencies in north Sweden probably depend on the Lappish influence, while the low frequencies in central Sweden may be a sign of an eastern influence.

ii. *The C-gene*

The heterogeneity between the eleven main regions is not significant ($0.05 > P > 0.02$). This depends partly on the fact that some of the



Map 33. Chromosome frequencies in the main regions (in order from the top: CDe, Cde, cDE, cdE, cDe and cde).



Map 34. Distribution of the C gene in Sweden.

main homogeneous areas of the map extend across several main regions, and this tends to level off differences between the main regions. Some features of the map are, however, significant — for instance, the difference for the frequency of C-negative individuals between main regions I, II, III and main regions IV, V, VI ($\chi^2=8.08$, 1 d.f., $0.01 > P > > 0.001$). Further, the frequency in central Sweden (main region VII and subregions 3, 5, 6, 7, 8 of main region VIII) is significantly higher than that further north (Main regions IV, V, VI, $\chi^2=7.89$, 1 d.f., $0.01 > > P > 0.001$). The higher incidence of frequencies in Scania and on Gotland is not significant.

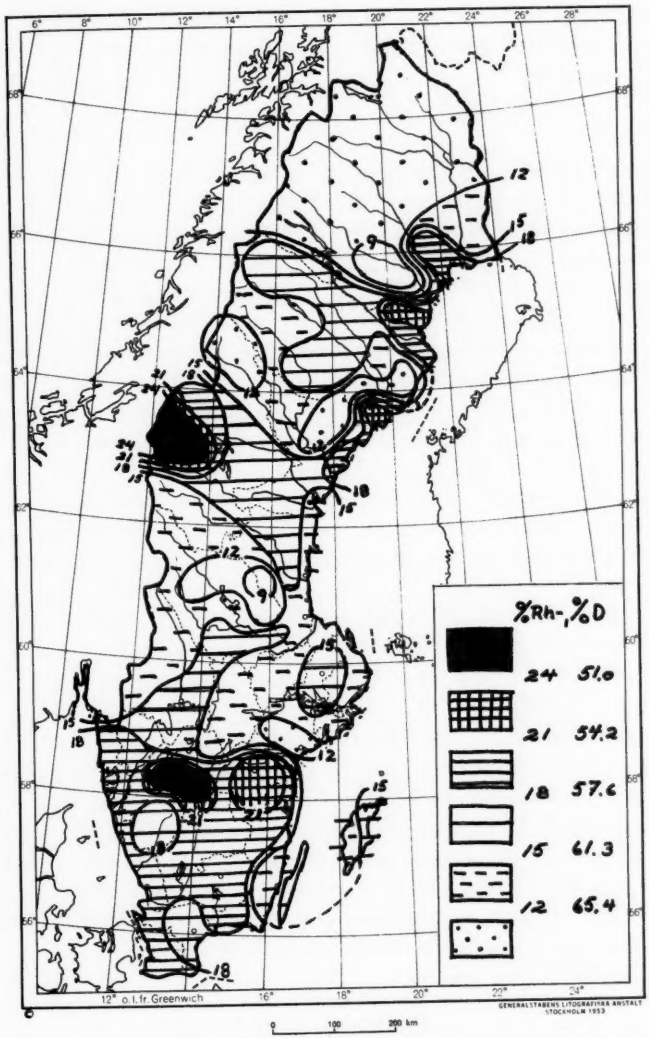
In the map of MOURANT (1954) all Sweden has more than 40 per cent C-gene frequency and Lapland has a value above 50 per cent. The only area in Europe which has a frequency lower than 40 per cent is Ireland. On Map 34 we find, however, relatively large areas with frequencies below 40 per cent. One of those areas is located in western Jämtland which suggests western immigration from Trøndelagen (Norway). There is one low frequency area in central Sweden (Värmland—Dalecarlia) and another in southern Sweden. High C-frequencies indicating an eastern influence are found in northern Sweden and in a girdle across central Sweden. (Note that roughly the same distribution of the eastern influence was demonstrated by the B-gene.)

iii. *The D-gene*

Map 35 is based on data for about 80,000 individuals. The variation of the D-gene has been illustrated by mapping the frequency of D-negative individuals. The isarithms have been drawn with 3 per cent intervals.

The frequencies of D-negative individuals show a significant heterogeneity. The frequency is high in south Sweden, in Jämtland, in the north Swedish coastal area and on Gotland. Low frequencies are found partly in north Sweden, partly in central Sweden. The low frequencies in the north may depend on both Lappish and Finnish influence, while those of central Sweden may be due to an eastern influence.

Notably high frequencies are found in western Jämtland and in Västergötland. Frequencies of 24—25 per cent have been observed. These are among the highest recorded in Europe. As high frequencies of D-negatives are thought to be indicative of Early European population elements (cf. BOYD, 1950), the results are highly interesting from an anthropological point of view.



Map 35. Distribution of the D gene and the frequency of Rh-negatives in Sweden.

The map shows two likely immigration paths for the d-gene into Sweden — one path from southwest Sweden up toward central Sweden and another past Jämtland and farther toward the south and the north along the coast.

iv. *The E-gene*

A highly significant heterogeneity for the E-gene is found in Sweden. According to MOURANT's map E-frequencies in Sweden should be between 15 and 20 per cent. The series of Swedish Lapps (ALLISON et al., 1956) showed an E-frequency of 25.2 per cent. Norwegian Lapps (ALLISON et al., 1952) had 18.0 per cent, while the Vittangi nomads (ALLISON et al., 1956) had a very low frequency. The last mentioned value is among the lowest obtained in Europe. Similar frequencies have been found only among Basques and in the populations of north Africa.

As seen in Map 36 the greater part of Norrbotten and Västerbotten counties and an area in central Sweden have E-frequencies above 20 per cent. According to MOURANT's map, frequencies above 20 per cent should be found only in America and Greenland. However, no conclusions can be drawn concerning the relationship between the populations of Greenland and Scandinavia, because of the total lack of information on Rh-subgroups from the vast Soviet territory. It is possible that the E-frequencies are high towards the east. The fact that the high E-frequencies in Sweden show the same geographical bicentricity as other "east criteria" (e.g., the high B-frequencies) supports this assumption.

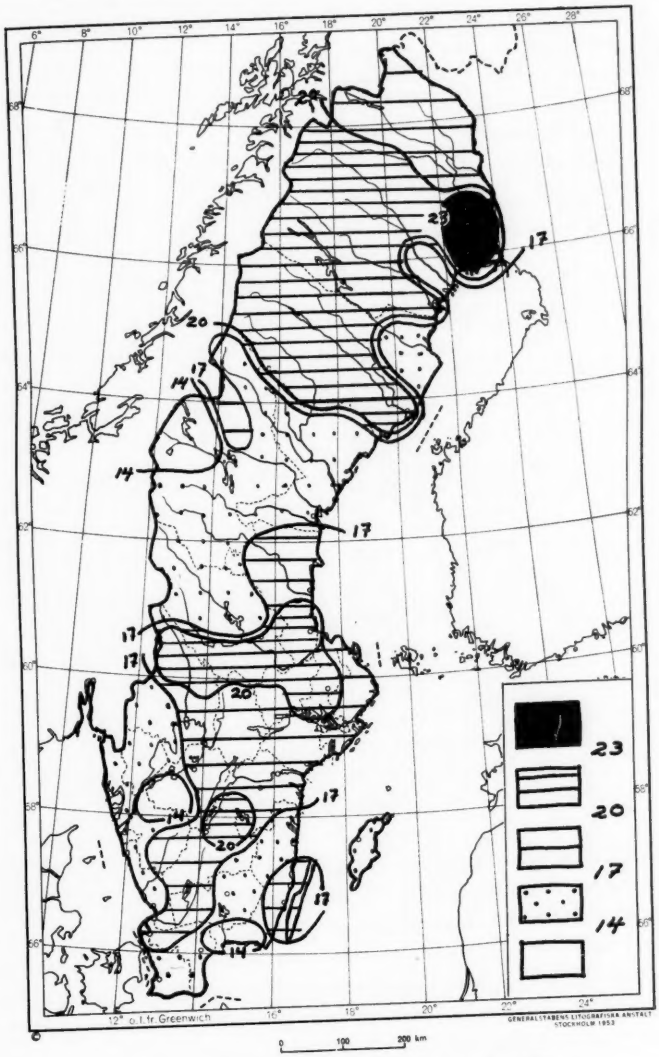
In this way it seems possible to make tentative predictions by calibrating genes of somewhat uncertain geographical distribution against genes with well known distributions (e.g., the A-, B-, and 0-genes).

As the pure Swedish Lapps seem to have very low E-frequencies, a low frequency of the E-gene might be expected in the total population of north Sweden. This is, however, not the case. The E-frequencies are, on the contrary, higher here than elsewhere in Sweden. This may depend on an eastern influence with a high E-frequency.

3. The MN-system

a) THE MATERIAL

The consistency is satisfactory for the total material and for all main regions. Investigators sometimes encounter difficulty in obtaining MN-



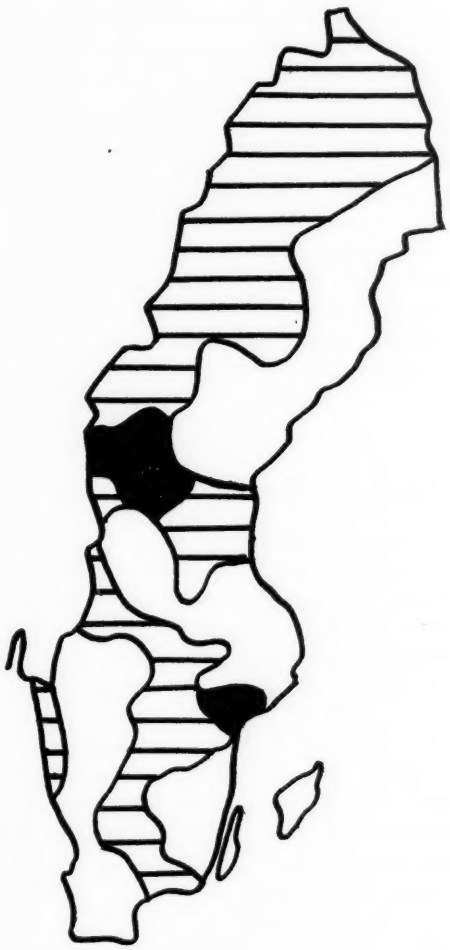
Map 36. Distribution of the E gene in Sweden.

TABLE 112. *MN groups and gene frequencies in the main regions.*

Main regions	MM	MN	NN	n	χ^2	M-gene	N-gene
I	213	281	84	578	0.31	61.16	38.84
%	36.85	48.62	14.53	100			
II	145	208	51	404	3.16	61.64	38.36
%	35.89	51.49	12.62	100			
III	144	197	57	398	0.51	60.93	39.07
%	36.18	49.50	14.32	100			
IV	149	202	82	433	0.84	57.73	42.27
%	34.41	46.65	18.94	100			
V	154	240	94	488	0.0008	56.10	43.90
%	31.56	49.18	19.26	100			
VI	127	200	63	390	1.14	58.21	41.79
%	32.57	51.28	16.15	100			
VII	1.028	1.510	597	3.135	0.36	56.88	43.12
%	32.79	48.17	19.04	100			
VIII	438	731	258	1.427	2.43	56.30	43.70
%	30.69	51.23	18.08	100			
IX	409	637	246	1.292	0.007	56.31	43.69
%	31.66	49.30	19.04	100			
X	506	876	344	1.726	0.50	54.70	45.30
%	29.32	50.75	19.93	100			
XI	57	96	33	186	0.46	56.45	43.55
%	30.64	51.61	17.75	100			
Total	3.370	5.178	1.909	10.457	0.002	56.99	43.01
%	32.23	49.52	18.26	100			

data consistent with expected frequencies. An excess of heterozygotes is commonly obtained, which has given rise to theories concerning monohybrid heterosis in the MN-system (cf. RACE and SANGER, 1950). The good consistency demonstrated by the present material is no doubt due to the rigorous testing methods used at the State Laboratory for Forensic Chemistry in Stockholm where this material has been typed under the supervision of Dr. B. JONSSON.

It may be of some interest to map the regional variation in the defiiency of heterozygotes. In isolated areas such a discrepancy may be expected through inbreeding increasing the frequency of homozygotes. Due to the difficulties involved in the serological technique of the MN-



Map 37. Observed deficiency of MN heterozygotes (marked with lines). Black areas: significant deficiency.

system such an undertaking may seem daring. This material is, however, of such a technical quality, that serological misclassification must be extremely rare. Further the material has not been tested in regional contingents, but samples from single individuals have been sent from all over the country one by one during a considerable time. Hence the risk of occasional technical errors for certain regions is small. Thus the deviations from the panmictic equilibrium distribution in the samples

may be looked upon as a measurement of the population structure. The difference between expected and observed frequencies of the MN-heterozygotes was calculated for all subregions. On Map 37 areas showing a deficiency of heterozygotes are marked with lines. Areas with a significant deficiency are black. It is evident that no mosaic picture is obtained. The areas with deficiencies are lying together. Thus despite the fact that the deviations are not significant for each single area the total picture may give some useful information.

The picture shows good agreement with expected traits judged from demographical data. The North-Swedish inland area is known to be more isolated than the coastal area. The "girdle" across South Sweden corresponds to the border zone between the main anthropological groups of South Sweden (cf. LUNDMAN, 1946).

b) VARIATION

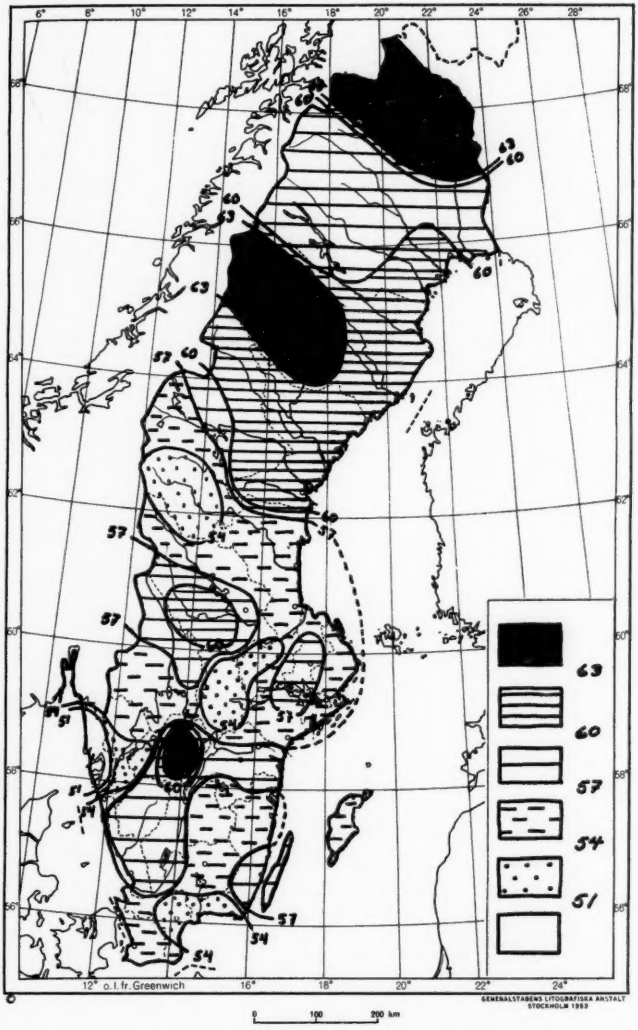
There is a significant heterogeneity for the frequency of $\frac{2MM+MN}{2n}$ between the main regions ($\chi^2=27.888$, 10 d.f., $0.01 > P > 0.001$). In this case the calculations have been based on the allelic populations. GLASS (1954) has shown that the statistical significance of the differences in MN-frequencies between six endogamous groups from India (SANGHVI and KHANOLKAR, 1949) may become entirely different when testing the differences for genotypic frequencies instead of fenotypic ones.

In the above-mentioned example where the material consists of inbreeding groups it remains uncertain whether the significant phenotypic differences depend on different degrees of inbreeding or on different frequencies of alleles. In the Swedish material, also, a considerable heterogeneity is found when testing the heterogeneity for phenotypical frequencies.

c) MAP

The highest M-frequencies are found in the counties of Norrbotten and Västerbotten. In Dalecarlia and Västergötland the frequencies are also relatively high.

Low frequencies are found in central Sweden, Jämtland, Bohuslän and Blekinge. The lowest value is found in Bohuslän (about 48 per cent). In Europe such low M-frequencies have been found only in the southwest and among the Lapps.



Map 38. Distribution of the M gene in Sweden.

Since the Lapps have low M-frequencies, it might be expected that relatively low frequencies would be found in northern Sweden. The eastern influence in north Sweden is, however, considerable which tends to increase the M-frequencies. The Norwegian Lapps (who are thought to be more mixed) have higher frequencies.

Other "east-criteria" than the M-frequency (e.g., the B- and the E-gene) showed a bicentricity, the highest values being found in north and central Sweden. The M-gene map does not show this bicentricity equally clearly. Dalecarlia has a relatively high M-frequency, but in Närke and Västmanland the frequencies are low. A path with lower frequencies runs from the Mälar district up through Jämtland (see Map 38).

4. The P-system

a) THE MATERIAL

No control of the reliability of the genetical composition of the material is possible. The frequencies of the P- and p-genes are shown in Table 113 below.

TABLE 113. *P groups and gene frequencies in the main regions.*

Main regions	P+	%	P−	%	n	P-gene	p-gene
I	441	76.30	137	23.70	578	51.32	48.68
II	308	76.27	96	23.73	404	51.29	48.71
III	311	78.14	87	21.86	398	53.25	46.75
IV	347	80.14	86	19.86	433	55.43	44.57
V	400	81.97	88	18.03	488	57.54	42.46
VI	293	75.12	97	24.88	390	50.12	49.88
VII	2.402	76.62	733	23.38	3.135	51.65	48.35
VIII	1.153	80.80	274	19.20	1.427	56.18	43.82
IX	1.035	80.11	257	19.89	1.292	55.40	44.60
X	1.404	81.35	322	18.65	1.726	56.81	43.19
XI	147	79.03	39	20.97	186	54.20	45.80
Total	8.241	78.81	2.216	21.19	10.457	53.97	46.03

b) VARIATION

A significant heterogeneity is seen for the frequency of P-negative individuals ($\chi^2=30.983$, 10 d.f., $P < 0.001$). Within the P-system there exists an intermediate category between P+ and P—, which is hard to

classify. Thus, in the P-system the question of statistical significance is to a very high degree dependent on the reliability of the testing methods. As previously mentioned, this material has been tested with a very rigorous method and data for children have been omitted. Therefore it seems very likely that a significant variation for the P-gene exists.

c) MAP

The highest frequencies are found in south Sweden (Bohuslän, Västergötland and Småland), and relatively high frequencies in the counties of Gävleborg and Jämtland and along the coastal area of north Sweden. Low P-frequencies are found most markedly in Lapland, but also in Dalecarlia and Uppland. The difference between coast- and inland populations of the counties of Norrbotten and Västerbotten is significant. The population of central Småland also shows significantly lower P-frequencies. (See Map 39.)

5. The main population constituents of Sweden

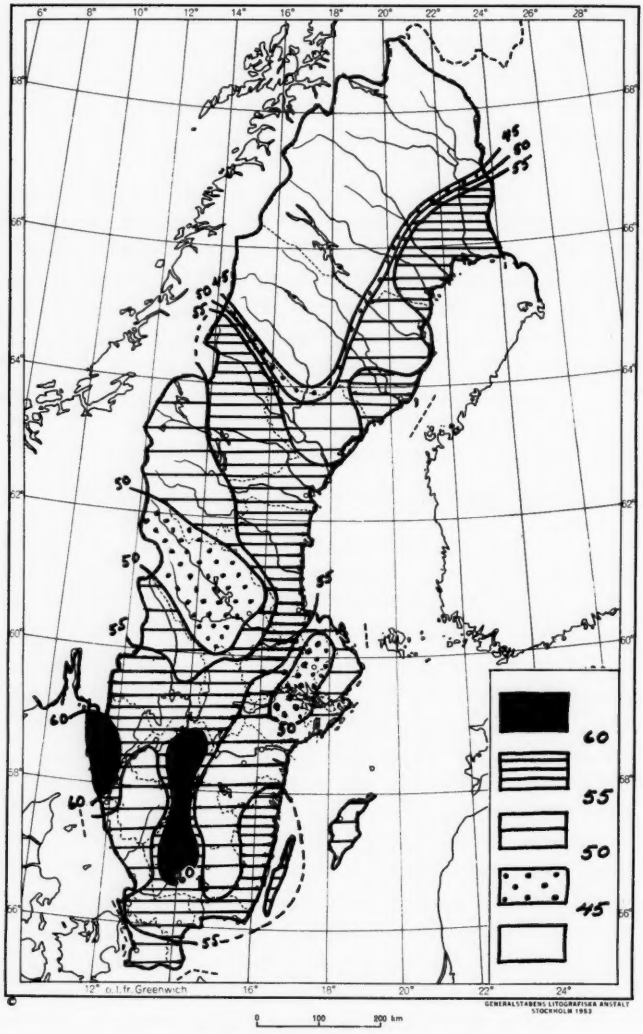
a) THE WEST EUROPEAN INFLUENCE

i. *General*

An introductory review of the scientific discussion concerning the occurrence of cromagnid population remnants has been given (cf. p. 14). Anthroposystematically, LUNDMAN (1952 b) divided the Cromagnid remnants into a tall, dark group in Scandinavia, Ireland and North Africa (the Palaeatlantic type) and a dark group with lower stature in southwest Europe (the Berids). In all maps he has shown hesitation concerning the classification of the Basques. In 1952 he classified them as Berids, but in 1957 b as Palaeatlantids.

MOURANT (see CHALMERS et al., 1949) has discussed and mapped the composition of the European population. He divides the population of Europe into four main groups and believes that the Basques represent the oldest population element of west Europe, since in nearly every respect their blood groups differ from those of the population of east Europe. The Celts, who share the high 0-frequencies of the Basques, are thought to be the next oldest element. The Berbers have — although with some hesitation — been included in the Celt group.

Comparing the anthropometrical classification by LUNDMAN and the serological classification by MOURANT, there is a rather good agreement



Map 39. Distribution of the P gene in Sweden.

on the occurrence of Early European populations. LUNDMAN's Palaeatlantids correspond roughly to the high 0 group (Basque and Celt groups), with the exception that MOURANT's map lacks information on the now discovered high 0-frequencies in Scandinavia.

ii. *West European elements in Sweden*

The variation of the 0-frequencies in Sweden indicate that the West European influence in northern Sweden is strongest in Ångermanland and the east coast. In southern Sweden this influence is strongest in the western parts and especially in Västergötland.

High frequencies of Rh-negative individuals also indicative of west European elements are found in southern Sweden, in western Jämtland, and in the north Swedish coast area. Although there is no detailed agreement in the 0- and Rh-variations, the same tendency to a south—north bicentric distribution of the high frequencies is found in both cases. In the strongly pronounced high 0-area in Ångermanland—Västerbotten the frequency of D-negative individuals is not high throughout. In the area in southern Västergötland where the highest 0-frequency of south Sweden was found, the frequency of D-negative individuals is somewhat lower than in other regions. Southeast Sweden has rather high frequencies of Rh-negative individuals but not high 0-frequencies. There is thus some disagreement in the detailed distribution of the highest 0- and Rh-frequencies, which possibly permits an assumption of the existence of two main west European elements in immigrations to Sweden. A similar condition has been observed in Ireland, where the highest frequency of Rh-negative individuals is found in the east and the highest 0-frequency in the west (HACKETT, DAWSON and DAWSON, 1956).

The degree of intermixture between two base populations may be calculated if the gene frequencies of the base populations and the hybrid population are known. If we wish to calculate the west European admixture in the Swedish population we may consider the gene frequencies for e.g. the Basques representative for "pure" west Europeans. The gene frequencies for the hybrid populations are easily obtained, but concerning the gene frequencies of the other base population we have no reliable estimates. Hence a calculation of the west European influence based on the gene frequencies does not seem advisable.

Instead therefore I have tried to give a rough estimate of the degree

of western influence by combining the 0- and Rh-data according to the following scale:

Points	1	2	3	4	5
High 0, more than	55	60	65	70	75 %
High frequency of D-negatives, more than	15	17	19	21	23 %

According to this scale, a population of pure Basques will get 10 points, the population of Ireland 5—7 points, the population of Finland 1 point and the Swedish mean population 3 points. The points for different Swedish populations have been plotted on Map 40. On this map, areas inhabited by populations with more than 4 points have been marked with lines. This should indicate areas with a west European influence stronger than the mean for Sweden. From the map it is clear that the strongest influences are found in south Sweden, Jämtland, Ångermanland, southern Västerbotten, and in the north Swedish coastal area. The island of Gotland also shows some western orientation. The only region in south Sweden which is not west-influenced is the Kalmar area, which we earlier have shown to be east-influenced. Otherwise there is a large homogeneous area in the south with a kernel area (northern Västergötland and western Småland). The western influence in the northeast coastal area is not homogeneously distributed all over the area, but restricted to certain areas — the lower parts of the valleys of the Luleå- and Skellefteå-rivers.

The feeblest west European influences tested in this way are obtained in Lapland, in Södermanland-Närke and in the Kalmar area. It may be noted that the kernel area for LUNDMAN's inner Scandinavian stock has very low figures.

The province of Dalecarlia is said to contain the strongest Early European influence in Sweden (LUNDMAN, 1945, 1946 and 1952 c). Two different populations are involved in the discussion concerning the Dalecarlian Type — 1) the Tydal group, and 2) the stock of the Scandinavian inland.

1) In Dalecarlia where LUNDMAN has described the Tydal type, also called the Tydal Race (LUNDMAN, 1940), no marked similarities with the west European blood group frequencies have been found. Thus the serological data do not support the hypothesis of a special west European race in northern Dalecarlia.

6° 8° 10° 12° 14° 16° 18° 20° 22° 24° 26° 28°
12° o.l fr Greenwich
16° 18° 20° 22° 24°
0 100 200 km
GENERALSTABENS LITOGRAFISKA ANSTALT STOCKHOLM 1953

Map 40. Variations of West European influence in Sweden. Areas marked with lines = West European influence stronger than the mean for Sweden.

2) The stock of the Scandinavian inland (the dominating type is called the Västmanland type) has also been thought to represent a west European population. LUNDMAN (1946) assumed immigrations to Dalecarlia from the southwest beyond Denmark. Serological characteristics such as high B-, high A_1-, and low frequency of Rh-negatives in the kernel area suggest, however, that this stock is of eastern origin. Furthermore the greyish-light eye pigmentation, low stature and high frequency of concave nasal bridge profiles also suggest an eastern origin.

It follows that the most prominent west European influence exists north and south of Dalecarlia and not within this province.

b) THE EASTERN INFLUENCE

The main eastern influence in Sweden is thought to originate from the so called East Baltic race. The name East Baltic was suggested by NORDENSTRENG (1926), who stated that traces of this race to a greater or less degree are detectable throughout northwestern Europe. COON (1939) maps an East Baltic influence in central Sweden. This was probably based more on a knowledge of the Finnish immigrations during the sixteenth and seventeenth centuries than on real anthropometrical evidence.

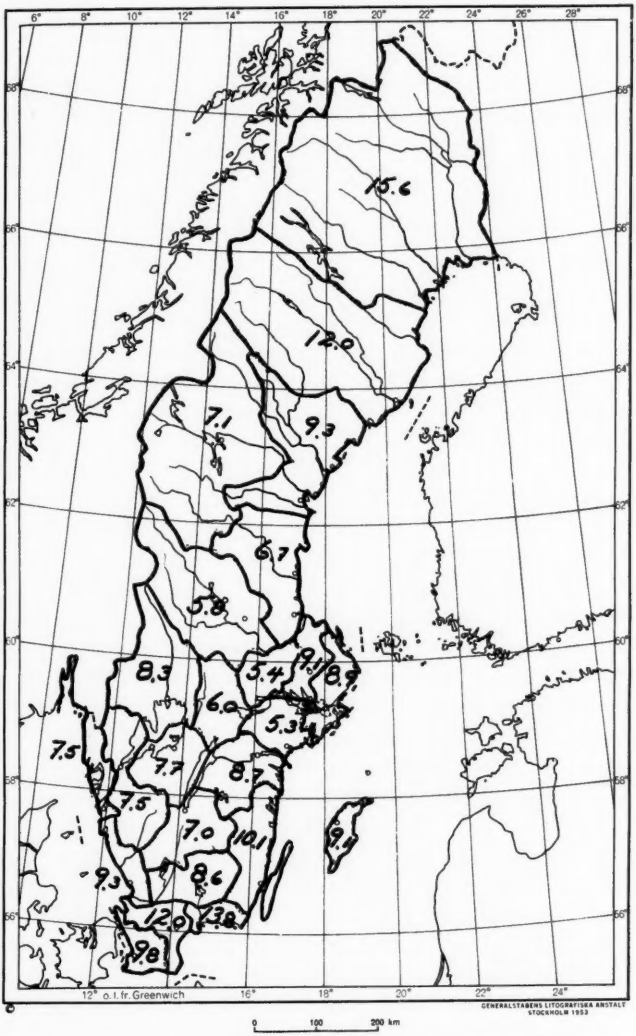
LUNDMAN (1945), on the contrary, claims that the Finnish immigration to Dalecarlia and the rest of central Sweden has left no considerable racial traces, and in his thesis he gives little space to discussing the Finnish influence.

The frequency of purer East Baltic types is shown on Map 41 a (after LUNDBORG and LINDERS, 1926). Individuals with light eye- and hair-color, stature below 173 cm, and cephalic index between 80—85 were designated pure East Baltic types.

Eastern influences in general are indicated by high A_1- and B-frequencies. When using the M-frequency also as a systematic character, the East Baltic elements (high B, high M) may be separated from other eastern elements.

I have tried to combine the M- and B-frequencies in the following way in order to get a rough measurement of the East Baltic racial influence in Sweden.

Character	Points				
	1	2	3	4	5
High B-frequency-above	7	9	11	13	15 %
High M-frequency-above	50	54	58	62	66 %



Map 41 a. Frequency of purer East Baltic types by counties (after LUNDBORG and LINDERS, 1926).

Map 41 b. East Baltic influence in Sweden by combination of B- and M-genes. Areas marked with lines: East Baltic influence stronger than the mean for Sweden. Denser lines: stronger influence.

On the scale above, a pure East Baltic population will get 10 points and the Swedish mean population 3 points. The variation of this index between different Swedish part populations is shown on Map 41 b. Areas with 4 and 5 points, which are assumed to possess an East Baltic influence, stronger than the mean for Sweden, have been marked with lines, and areas with 6 points and more are considered to possess a still stronger East Baltic influence (denser lines).

According to this map the strongest East Baltic influences are found in the northeast and in Dalecarlia. A feeble east Baltic influence is found over almost all of northern Sweden, in central Sweden and in southeast Sweden. In eastern Dalecarlia, Närke and Västmanland, howver, the east Baltic influence is not especially pronounced. This agrees very well with the anthropometrical map, which showed a low frequency of east Baltic types in the same area. The high frequency of east Baltic types in south Sweden (Scania, Halland, Blekinge) has no correspondence on the serological map. The short, brachycephalic element in Denmark and south Sweden is referred to as alpine by LUNDMAN (1943). This may explain the lack of agreement between the two maps concerning south Sweden.

There is little doubt that the area in central Sweden (Dalecarlia, Närke and Västmanland) with low East Baltic intensity as to serological characters, really has eastern influences. This is shown by the comparatively high B, the high A_1 and the low frequency of Rh-negatives. The cause of the low East Baltic intensity in central Sweden on the serological map is, as previously mentioned, however, the low M-frequency. Populations with high B and relatively low M may be found somewhere in the Baltic states or further south. Latvians, as well as the Finns, have been proved to have high M. The Estonians, however, have high B and an M-frequency below 60 per cent.

BECKMAN and KALLSTENIUS (1958) carried out an investigation of Estonian immigrants. The aim was mainly to get some idea of A_1-A_2-frequencies in Estonia. Since it is known that the Finns have rather high A_2-frequencies and the Latvians low A_2-frequencies it is interesting to know if the Gulf of Finland represents a border for the high A_2-frequencies so that low A_2-frequencies are to be found also in Estonia. The ABO-data (Table 114) show that there is a rather low A_2-frequency in Estonia (significantly lower than in Finland).

Thus in the area south of the Gulf of Finland the same combination of low A_2 and high B as in central Sweden is found. MOURANT (1954) has stated that the relatively high A_2-frequency in the Finns may depend

TABLE 114. *A_1A_2B0 groups and gene frequencies of Estonians.*

A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
50	7	33	6	1	54	151	1.89	20.9	3.4	14.4	61.3	98.16

on a slight Lappish influence. The Lapps are known to have spread over all Finland in earlier times but not as far as Estonia. In support of this there is a lower A_2-frequency in Estonia.

c) THE LAPPS

The Lapps have for a long time attracted the attention of anthropologists. Several theories concerning their origin have been presented; they have been considered to be simply a Mongolian group or a hibernating Ice Age relict of a very old Early European population (cf. LUNDMAN, 1952 a).

i. *Demography*

Section II of "The Race Biology of the Swedish Lapps" (1932) deals with the demography of this people. WAHLUND summarizes their demographical characteristics thus: The mortality is on the whole normal for European conditions and has decreased in the advanced age groups during the investigation period (1791—1890). No considerable geographical variation for the mortality seems to exist. Mortality among the nomadic Lapps is higher than among the settled ones, and is particularly high in newborn infants and women in the childbearing ages. The age of marriage is somewhat lower for the nomads than for settled Lapps, but has increased for all Lappish groups during the investigation period.

Fertility (highest in Jukkasjärvi) is relatively low in the nomads. WAHLUND claims that the high abortion frequency among the nomadic Lapps decreases their general fertility. The Lappish nomads show demographical characteristics normal for European populations, a fact which contradicts the popular conception of the Lapps as a "dying race".

ii. *Earlier serological investigations*

Most of the early AB0-investigations on Swedish Lapps showed very high A- and low B-frequencies. One series by RIETZ (quoted by STRENG, 1935), however, deviates with a low A-frequency. This series showed a

significant inconsistency with expected values ($\chi^2=6.91$, 1 d.f., $0.01 > > P > 0.001$). Some sort of serological misclassification may possibly be the reason of the low A-frequency. The unusually high 0-frequency makes it probable, for example, that an anti-A reacting very feebly with A_2 may have been used, and thus some A_2-individuals were classified as group 0.

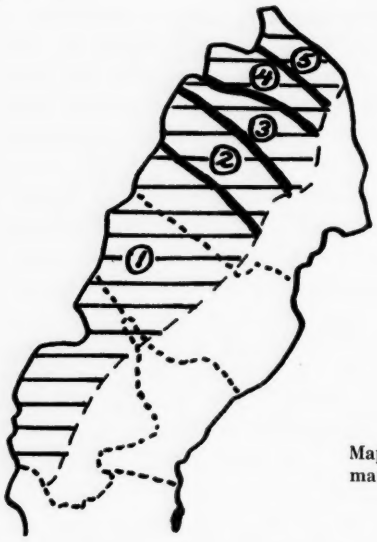
Another series on Lappish children from nomad schools by SCHÖTT (1926) had an A-frequency of 34 per cent. This series was composed of two samples (the nomad schools of Jukkasjärvi and Lannavaara-Soppero). In the sample from Jukkasjärvi the A-frequency was very low, but in Lannavaara-Soppero very high (above 40 per cent).

A highly significant difference in the frequency of A+AB was seen between the two series ($\chi^2=18.30$, 1 d.f., $P < 0.001$). The variation of B was inconsiderable. The two nomad schools were probably tested at different periods of time, and it is possible that the Jukkasjärvi series suffered some sort of misclassification — for instance through the use of an anti-A reacting very feebly with A_2.

Thus, if we disregard series which are for some reason or other suspect, the Swedish Lapps seem to be characterized by a high A-frequency (mostly towards 40 per cent) and a low B-frequency (below 5 per cent). The Norwegian and Kola Lapps have, however, a B-frequency above 10 per cent. Blood group investigations carried out during the last years by ALLISON et al. (1952 and 1956) have partly confirmed earlier results and partly contributed new data to the anthropological knowledge of the Lapps concerning other serological systems than the AB0-system. These investigations have further stressed the genetical peculiarity of the Lapps and make the question of the origin of the Lapps still more complicated. Thus, some traits point to an eastern influence — e.g., Rh and Duffy — while other traits are west European e.g. AB0 (low B) and MNSs (low M). The Lapps have, furthermore, certain characteristics not shared with any other population — e.g., the enormously high A_2-frequency.

iii. *New serological data*

Together with Prof. B. BROMAN, Drs B. JONSSON and T. MELLBIN (1959), I have investigated the blood groups of all Swedish nomad school children. The bloods from Norrbotten county were collected by Dr MELLBIN and from the southern schools by myself. The typing was done by Professor BROMAN and Dr JONSSON at the State Laboratory for



Map 42. Location of the Lapp samples (area marked with lines inhabited by Lapps).

Forensic Chemistry. By the courtesy of my collaborators, I can present an analysis of the results for 419 individuals.

The fact that the individuals in this investigation belong to nomad schools means that most of them are genuine Swedish nomad Lapps. This should be kept in mind when comparing the results with the earlier investigation of Swedish Lapps by ALLISON et al. (1956).

The individuals have been grouped into five regional groups (cf. Map 42). In Norrbotten county the classification has been made according to parish of birth. All individuals born south of Jokkmokk have been pooled together. For help with the regional classification I am indebted to Dr. I. RUONG, Inspector of the nomad schools.

A_1A_2B0

The AB0-data are shown in Table 115. The consistency of the material is satisfactory. The earlier results by ALLISON et al. (1956) are confirmed. The A_2-frequncy is even higher in this material especially for the southern samples where it is 42 per cent. There is a continuous decrease of A_2-frequencies towards the north. The differences are, however, not significant, e.g. the difference between Jukkasjärvi-Karesuando

TABLE 115. *A_1A_2B0 groups and gene frequencies of the Swedish lapps* (BROMAN et al., 1959).

Region	A_1	A_2	B	A_1B	A_2B	0	n	χ^2	p_1	p_2	q	r	p+q+r
1 Jämtl., Västerb., Arjeplog	14	69	4	1	2	28	118	0.34	6.6	42.2	3.0	48.2	100.65
2 Jokkmokk	7	44	1	0	0	19	71	0.74	5.1	42.0	0.7	52.2	99.43
3 Gällivare	6	27	2	3	0	11	49	0.002	9.6	38.8	5.2	46.4	100.11
4 Jukkasjärvi	12	61	6	0	4	40	123	0.03	5.0	33.9	4.0	57.1	99.83
5 Karesuando	8	26	2	0	1	21	58	0.03	7.2	29.9	2.6	60.3	99.81
Total	47	227	15	4	7	119	419	0.05	6.3	37.2	3.1	53.4	99.87

TABLE 116. *A_1A_2B0 gene frequencies. — Comparison.*

Region	A_1	A_2	B	0	n
Jämtl., Västerb., Arjeplog	6.6	42.2	3.0	48.2	118
Jokkmokk	5.1	42.0	0.7	52.2	71
Gällivare	9.6	38.8	5.2	46.4	49
Jukkasjärvi	5.0	33.9	4.0	57.1	123
Karesuando	7.2	29.9	2.6	60.3	58
ALLISON et al. 1956 * Main series	4.5	32.3	2.1	61.1	193
ALLISON et al. 1956 * Vittangi Lapps	5.4	36.9	2.7	55.0	153
ALLISON et al. 1952 * Norwegian Lapps	15.9	35.7	13.9	34.5	183
The total population of Lapland	17.2	17.5	5.9	59.4	188
The population of Norrbotten county	17.5	14.2	8.1	60.2	578
The Swedish population	22.17	8.56	7.68	61.59	10.457

* Shortened figures from the original data

and the other regions gives $\chi^2=3.71$, 1 d.f., $0.1 > P > 0.05$. The 0-frequencies are higher in Jukkasjärvi-Karesuando as compared to the southern regions ($\chi^2=4.41$, 1 d.f., $0.05 > P > 0.02$). The A_1- and B-genes show no significant variation. In Table 116 a comparison of the gene frequencies for some Lappish and non-Lappish samples has been made.

Rh

In accordance with earlier investigations the frequency of Rh-negative individuals is low. The frequency of the D-gene shows no significant heterogeneity ($\chi^2=2.61$, 4 d.f., $0.7 > P > 0.5$).

The C-gene ($\chi^2=16.31$, 4 d.f., $0.01 > P > 0.001$) and the E-gene ($\chi^2=14.13$, 4 d.f., $0.01 > P > 0.001$, however, show heterogeneity. A still higher heterogeneity is demonstrated by the C^w-gene ($\chi^2=38.55$,

TABLE 117. *Rh groups of the Swedish lapps* (BROMAN et al., 1959).

Region	CCD	C^wCD	CcD	C^wcD	CcDE	C^wcDE	DEE	DEe	D	C	E	Rh-	n
1 Jämtl., Västerb., Arjeplog	35 29.66	1 0.85	32 27.12	6 5.08	13 11.02	1 0.85	2 1.69	12 10.17	7 5.93	0 0.00	0 0.00	9 7.63	118 100.00
2 Jokkmokk	15 21.14	11 15.49	19 26.76	5 7.04	10 14.08	1 1.41	0 0.00	5 7.04	1 1.41	0 0.00	0 0.00	4 5.63	71 100.00
3 Gällivare	22 44.91	3 6.12	3 6.12	1 2.04	11 22.45	1 2.04	2 4.08	3 6.12	1 2.04	0 0.00	0 0.00	2 4.08	49 100.00
4 Jukkasjärvi	30 24.39	24 19.51	33 26.83	16 13.01	12 9.75	1 0.81	0 0.00	2 1.63	2 1.63	0 0.00	0 0.00	3 2.44	123 100.00
5 Karesuando	13 22.42	5 8.62	16 27.59	7 12.07	1 1.72	2 3.45	0 0.00	6 10.34	3 5.17	0 0.00	0 0.00	5 8.62	58 100.00
Total	115 27.45	44 10.50	103 24.58	35 8.35	47 11.22	6 1.43	4 0.96	28 6.68	14 3.34	0 0.00	0 0.00	23 5.49	419 100.00

TABLE 118. *Frequencies of Rh-genes in the Swedish lapps* (BROMAN *et* al., 1959).

Region	D	d	C	C^w	c	E	e	n
1 Jämtl., Västerb., Arjeplog	72.4	27.6	49.1	3.4	47.5	12.7	87.3	118
2 Jokkmokk	76.3	23.7	49.3	12.0	38.7	11.3	88.7	71
3 Gällivare	79.8	20.2	62.2	5.1	32.7	19.4	80.6	49
4 Jukkasjärvi	84.4	15.6	52,4	16.7	30.9	6.1	93.9	123
5 Karesuando	76.6	29.4	41.4	12.1	46.5	7.8	92.2	58
Total	77.1	22.9	50.6	10.1	39.3	10.6	89.4	419

4 d.f., $P < 0.001$) which in this material has a remarkably high frequency.

In the earlier investigation ALLISON (1956) observed that the Lapps had the highest known frequency of C^w. He found it remarkable that the increase of C^w-frequencies northward and eastward in Europe

TABLE 119. *Rh-groups — comparison.*

Region	CD	CDE	DE	D	C	E	Rh-	n
Jämtl., Västerb., Arjeplog	62.7	11.9	11.9	5.9	0.0	0.0	7.6	118
Jokkmokk	70.4	15.5	7.1	1.4	0.0	0.0	5.6	71
Gällivare	59.2	24.5	10.2	2.0	0.0	0.0	4.1	49
Jukkasjärvi	83.8	10.6	1.6	1.6	0.0	0.0	2.4	123
Karesuando	70.7	5.2	10.3	5.2	0.0	0.0	8.6	58
ALLISON et al. 1956 Main series	51.3	24.4	19.7	1.0	0.0	0.0	3.6	193
ALLISON et al. 1956 Vittangi Lapps	75.2	7.8	6.5	2.6	0.0	0.0	7.8	151
ALLISON et al. 1952 Norwegian Lapps	60.1	14.8	18.0	3.8	0.6	0.0	2.7	183
The total population of Norrbotten	51.1	17.3	19.1	0.8	1.6	0.0	10.1	503

TABLE 120. *Chromosome frequencies* (BROMAN et al., 1959).

Region	CDe	C^wDe	cDE	cDe	cde	n
1 Jämtl., Västerb., Arjeplog	49.1	3.4	12.7	8.7	26.1	118
2 Jokkmokk	49.3	12.0	11.3	2.0	25.4	71
3 Gällivare	62.2	5.1	19.4	2.4	10.9	49
4 Jukkasjärvi	52.4	16.7	6.1	5.6	19.2	123
5 Karesuando	41.4	12.1	7.8	8.1	30.6	58
Total	50.6	10.1	10.6	6.1	22.6	419
ALLISON et al. 1956 Swedish Lapps	49.1	4.3	23.8	2.7	20.1	193
ALLISON et al. 1952 Norwegian Lapps	48.6	3.9	18.4	10.3	18.8	183

reached a peak in the Lapps. This investigation strongly indicates that the C^w-gene is a "typical Lappish" tracer gene in the same sense as the A_2-gene. The southernmost group, which corresponds to the area where the southern Lappish language is spoken has a significantly lower C^w-frequency. (Note that the A_2-frequencies show an increase towards the south.)

From Table 120 showing the chromosome frequencies it is evident that the cDE-frequency is not especially high in the Swedish Lapps as ALLISON (1956) has stated. In Table 119 different Lapp samples have been compared with a sample from the total population of Norrbotten county. ALLISON's material shows some similarities with the total population of Norrbotten but not with the Vittangi series and most of our samples which show higher CD-frequencies and lower DE-frequencies. ALLISON describes the material in the following way: "; most were settled forest workers and some were nomads, ———". The Vittangi Lapps were to a larger extent nomadic and therefore show a better agreement with our data. Thus, it is likely that the disagreements between ALLISON's material and ours are due to the fact that ALLISON's material is more mixed.

MN

The consistency of the material is not satisfactory for subregion 2. A very low M-frequency was found in all samples except for the

southernmost group. There is a significant difference between this group and the other samples ($\chi^2=16.81$, 1 d.f., $P<0.001$). The value obtained in the south is quite normal for Swedish conditions indicating an intermixing with the surrounding populations.

TABLE 121. *MN groups and gene frequencies* (BROMAN et al., 1959).

Region	MM	MN	NN	n	χ^2	M	N
1 Jämtl., Västerb., Arjeplog	38 32.20	59 50.00	21 17.80	118 100.00	0.01	57.2	42.8
2 Jokkmokk	13 18.31	44 61.97	14 19.72	71 100.00	**4.07**	49.3	50.7
3 Gällivare	4 8.16	27 55.10	18 36.73	49 99.99	1.97	35.7	64.3
4 Jukkasjärvi	15 12.20	65 52.85	43 34.95	123 100.00	1.62	38.6	61.4
5 Karesuando	11 18.97	28 48.27	19 32.76	58 100.00	0.01	43.1	56.9
Total	81 19.33	223 53.22	115 27.45	419 100.00	2.12	45.94	54.06

P

The P-frequencies are low except for the Karesuando area where they are similar to those of the total population of Norrbotten and the Norwegian Lapps. The difference between the Karesuando sample and the other samples gives $\chi^2=5.28$, 1 d.f., $0.05>P>0.02$.

TABLE 122. *P groups and gene frequencies* (BROMAN et al., 1959).

Region	P+	%	P−	0	n	P	p
1 Jämtl., Västerb., Arjeplog	72	61.02	46	38.98	118	37.6	62.4
2 Jokkmokk	46	64.79	25	35.21	71	40.7	59.3
3 Gällivare	26	53.06	23	46.94	49	31.5	68.5
4 Jukkasjärvi	73	59.35	50	40.65	123	36.2	63.8
5 Karesuando	44	75.86	14	24.14	58	50.9	49.1
Total	261	62.29	158	37.71	419	38.6	61.4

Kell

Only one Kell-positive individual was found. He belonged to the southernmost group. A very low frequency has been reported earlier. It seems likely that originally the Lapps lacked the Kell-antigen.

The results of the new data may be summarized as follows: There is a considerable heterogeneity among the Swedish nomad Lapps. The Lapps of the area where the south Lappish language is spoken are genetically different from those living further north. A very high frequency of the C^w-gene has been found among the nomads.

iv. *The Lappish influence in Sweden*

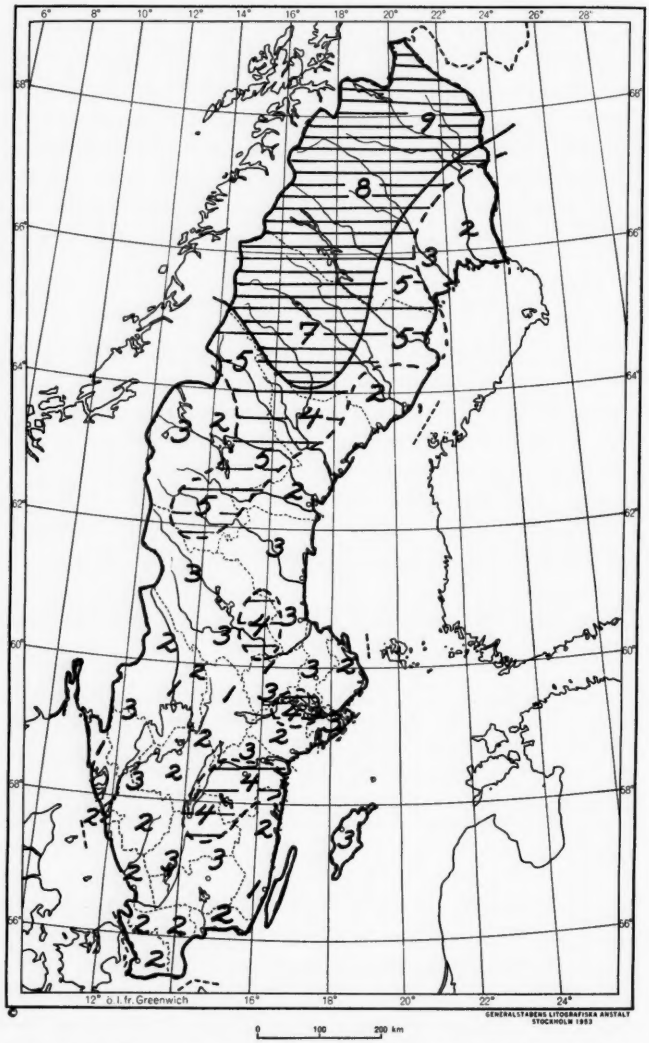
Since the A_2-gene has a very high frequency among the Lapps, the high A_2-frequencies (Map 30) may be taken as indicative of Lappish influence in the Swedish population. To summarize many serological characters as an index of genetical influence is more difficult in the case of the Lapps than, e.g., for the East European or West European race elements. This depends on the aforementioned fact that the Lapps show a mixing of eastern and western traits. High A_2-frequencies and low B- and P-frequencies may be regarded, however, as rather typical Lappish characters.

To get an index for "Lappish intensity", I have combined the B-, A_2-, and P-genes according to the following scale.

Characters	Lappish influence — points				
	1	2	3	4	5
Low B-frequency — below	7 %	6 %	5 %	4 %	3 %
High A_2-frequency — above	8 %	11 %	14 %	17 %	21 %
Low P-frequency — below	60 %	55 %	50 %	45 %	40 %

The Lappish intensity tested in the following way gives 15 points for Swedish Lapps. The Swedish mean population gets 3 points. The variation of this index based on the paternity material is shown on Map 43. Areas with 4 points or more have been marked with lines corresponding to a traceable Lappish influence. Areas with 7 points or more are marked with denser lines, indicating a stronger Lappish influence. It would be dangerous to assert that Lappish influences are really traceable in south and central Sweden.

There are some agreements between different Lappish indicator genes


6° 8° 10° 12° 14° 16° 18° 20° 22° 24° 26° 28°
12° ö.l.fr.Greenwich
16° 18° 20° 22° 24°
0 100 200 km
GENERALSTABENS LITOGRAFISKA ANSTALT
STOCKHOLM 1953

Map 43. Lappish influence in Sweden. Areas marked with lines: Lappish influence stronger than the mean for Sweden. Denser lines: strong Lappish influence.

north of the central Swedish low frequency area for A_2, e.g., in eastern Dalecarlia and in Gästrikland there is an increase of A_2-frequencies accompanied by a drop in B- and Rh-negative frequencies. In the area in Östergötland which shows a feeble Lappish influence on our synoptic map, a high Rh-negative frequency is found. Hence the high A_2-frequencies south of the central Swedish low frequency area for A_2 may depend on other influences (cf. BOYD's Early European group).

At first it may seem quite improbable that an ethnic group which nowadays constitutes only about 0.1—0.2 * per cent of the Swedish population may have left any detectable genetical traces at all. However, our possibilities of measuring the occurrence of Lappish remnants depend on the sensitivity of the method used. In this respect we have the advantage of knowing the A_2-gene, with its enormous frequency differences between the Lapps and other populations. We must also consider the rapid numerical increase in populations during the last few centuries. This increase has been especially pronounced in the population of northern Sweden. In 1750 there were only about 36,000 settled inhabitants in Norrbotten and Västerbotten counties together. Concerning the size of earlier populations we have no reliable data, but it seems reasonable to assume that the non-Lappish population was very small. The Lappish population, on the contrary, has, if not actually decreased in recent times, remained fairly constant. WAHLUND (1932) demonstrated that the birth- and death-rates for the Lapps were not significantly different from those of other European populations. In spite of this the Lappish population has not increased to any remarkable extent during the last centuries, because of a continuous "denomadization" of part of the Lappish population (through marriage, etc.) and subsequent assimilation into the settled population. This process has produced a continuous gene flow from the Lapps into surrounding populations — a process which has probably been going on since early times.

v. *Origin*

No clear similarities between the Lapps and any other known population can be found, either in serological or anthropometrical characteristics. This means that any effort to derive the origin of the Lapps through immigration from any other known population has little hope of success. The most reasonable explanation is perhaps that the original Lappish population was differentiated in northern Scandinavia through

* depending on the way of delimiting the Lappish population.

comparatively long isolation as a small group. Genetic drift is probably responsible for some of the variations found between the small Swedish groups. The peculiar blood group frequencies found in all Lapps have probably not originated through genetic drift alone. As the Lapps are thought to be a very old population, part of the peculiarities may be tentatively explained by long time isolation and selection against heterozygotes through serological incompatibility. Such selection tends to decrease the frequency of the less frequent allele at a certain locus. The low frequencies of the A_1-, cde-, cDE-, and K-genes are all consistent with such a hypothesis (cf. RACE and SANGER, 1958, pp. 310—313).

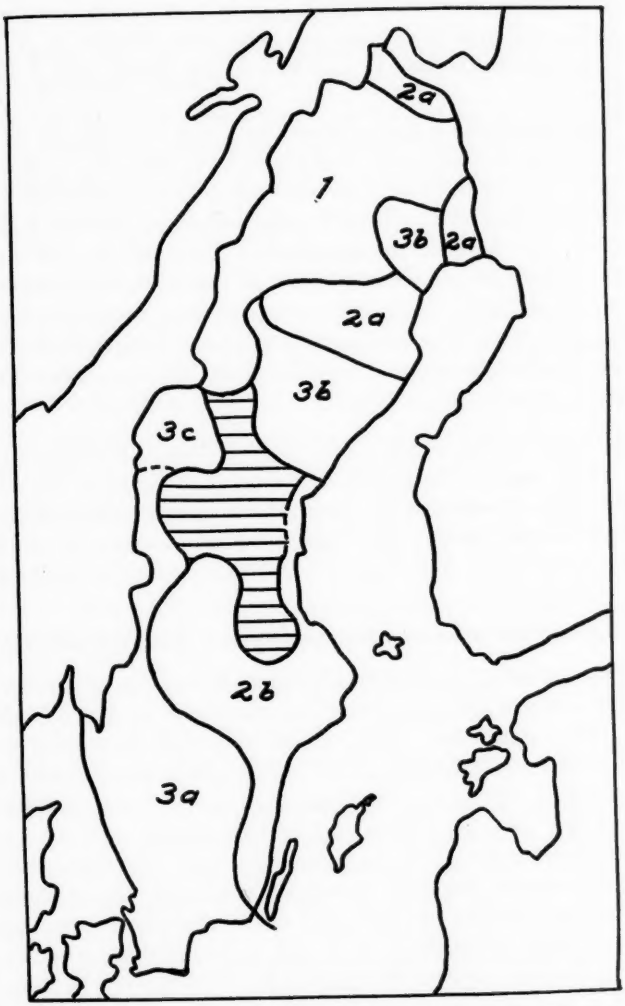
6. An attempt at a regional classification

I have made an attempt to summarize final results by a rough classification of the Swedish population into genetically different subpopulations. Naturally it is impossible to summarize on one single map all the details in the complicated system of mutual influence that are found in Sweden. Hence, the following map gives a description of the main features of the variation.

Areas with prevailing Lappish influence have been marked with 1, eastern influence with 2, and west European influence with 3. Areas which do not show any clearly detectable influences from either of the main populations have been marked with lines. (See Map 44.)

CLASSIFICATION

1. The population of this area shows a clearly detectable Lappish influence indicated by high A, high A_2, low B, low P, and a low frequency of D-negatives.
2. The populations of these areas have higher B-frequencies, indicating an eastern influence.
   a) These populations are characterized by high B combined with a comparatively high A_2 and M. Thus, this influence may be ascribed as most likely due to East Baltic race immigrations (east-Finnish tribes).
   b) This population is characterized by relatively high B combined with low A_2, partly low M and a low frequency of D-negatives. Although some late Finnish influence may exist in this population (e.g., in Dalecarlia and Uppland), its main eastern influence is probably older than the Finnish element.



Map 44. Classification of the Swedish population into genetically different subpopulations.

3. The populations of these areas show a relatively low A, high 0, and high frequency of D-negatives.
   a) Relatively high 0 is combined with high frequency of D-negatives, usually higher A_2 than in 2 b, and partly high P and very low M.
   b) This population is characterized by a high 0-frequency. In Ångermanland the frequency of D-negatives is high only in the coastal area. The typical west European traits have probably been modified by Lappish as well as Finnish influence, both of which have tended to diminish the frequency of D-negatives. The comparatively high M-frequency is probably due to the eastern influence.
   c) As previously mentioned, this area is not altogether west-influenced (cf. the relatively high B-frequency). As the western traits are predominant (very high frequency of D-negatives, low M) it has been included under 3.

In the large central Sweden area marked with lines, influences from all the three main anthropological elements of Sweden seem to have met. The eastern influence has come both from the north and the south (mainly from the south), the Lappish influence from the north, and the western influence both from the southwest and via Jämtland.

7. Agreements between serological and anthropometrical data

The classification of human races based on serological characteristics shows in the main agreement with that based on classical anthropology (BOYD, 1950). LAHOVARY (1949 and 1950) claimed that there is a connection throughout Europe between high blood group A frequency and brachycephaly. MOURANT (1954) stated that the Alpine band of high A frequency is in some way connected with the broad-headed "Alpine race". In Sweden no strict correspondence between high A frequency and brachycephaly has been observed. This might be expected since the high A frequencies of north and central Sweden are composed of entirely different proportions of A_1 and A_2. In northern Sweden where a great part of the A genes are A_2 there is a brachycephalic area, but in the high A area of central Sweden where A_1 dominates the population is dolichocephalic.

As previously mentioned LUNDMAN (1946) attempted to make a detailed anthropometrical classification of the Swedish population which may serve as an object of comparison. When comparing Map 2 (the

anthropometrical classification) and Map 44 (the serological classification) the following agreements are found:

a. The areas showing Lappish influence are of approximately the same extent on both maps.

b. The easterly influenced area in central Sweden (2 b) corresponds roughly to LUNDMAN's area of the stock of the Scandinavian inland.

c. The high B-frequencies in central Jämtland give some support to LUNDMAN's mapping of an influence from the stock of the Scandinavian inland here (cf. LUNDMAN, 1946 p. 67).

d. The borderline between the populations 3 a and 2 b (Map 44) corresponds fairly well to LUNDMAN's south-west-Swedish diagonal* which is a well-known border also from dialectal and demographical points of view. The minor subdivisions in Småland are also distinguishable serologically (cf. Main Region IX).

e. The serologically indeterminable area on Map 44 corresponds roughly to LUNDMAN's stock of Tröndelagen.

f. On the boundary between Dalsland and Bohuslän, LUNDMAN has indicated an influence of an old population. The serological data also point to an old western influence.

g. In the Luleå area LUNDMAN found a deviating dolichocephalic population. Serological data point to a southwestern influence.

h. FLODSTRÖM (1918) has earlier claimed that there is a south-west-Swedish influence in the stock of Västerbotten. LUNDMAN (1946) also discusses this possibility. This hypothesis is supported by the occurrence of high 0-frequencies in the stock of Västerbotten.

Only one main feature of the serological and anthropometrical classifications does not agree. That is the easterly influenced population of northern Västerbotten (2 a) and the rather sharp border between this population and the westernly influenced population (3 b) south of it.

No conclusive agreements with maps showing the intensity of the "Nordic race" have been found. Both the maps by DE GEER (see LUNDBORG and LINDERS, 1926) and LUNDMAN (1940 and 1946) seem, however, be in agreement that the strongest influence of the "Nordic race" should be found in the serologically indeterminable area (marked with lines on Map 44).

The main result of the comparison, however, shows many agree-

* Author's translation.

ments between anthropometrical and serological data. It is of great importance to physical anthropology that detailed comparisons of this type are performed. WATKIN (1956) has thus made a comparison between AB0 blood groups and anthropometrical data in Wales. Sweden is one of the most thoroughly investigated countries of the world as regards anthropometry. Hence, the possibilities of making comparisons between blood groups and anthropometry are especially favourable.

8. Blood groups, archaeology and history in Sweden

Some attempts to correlate archaeological findings with the present-day blood group frequencies have earlier been made (cf. MOURANT and WATKIN, 1952). Though the method has certain limitations some possible correlations between blood groups and archaeology in Sweden will be discussed below. This is done with all reservations for the insecurities which may be connected with comparisons of this kind.

a) THE OLDEST ELEMENTS

The early postglacial population of Europe may not necessarily have been genetically homogeneous. The Basques and the Lapps are both thought to represent remnants of Early European groups. Both have low B- and M-frequencies and a high frequency of the CDe-chromosome, but differ markedly as to the frequency of Rh-negatives. Further, the Lapps have an extremely high A_2-frequency and the Basques a high 0-frequency. The same combination of low B and high frequency of Rh-negatives shown by the Basques has also been found in Holland (VAN DER HEIDE et al., 1951). WATKIN (1956) claimed that the population of the isolated moorlands of Wales, with rather high B-frequencies were also descendants of a paleolithic group and that a high B-frequency should be an ancient phenomenon in western Europe and not a late importation from the east.

The following tentative accordances between serological and archaeological evidence for the occurrence of ancient population elements were found in Sweden.

i. Archaeological evidence suggests that since earliest times the archaeology of Scandinavia has been characterized by a dualism consisting of one cultural element derived from the southwest, and another more indeterminate element in northern Scandinavia. From the earliest postglacial times this dualism is expressed by the difference between

the Komsa and Fosna cultures (cf. SIMONSEN, 1957). The bicentric distribution of the high A_2-frequencies in Sweden may possibly be connected with such very old archaeological differences. The high A_2-frequencies north of the central Swedish low frequency area are combined with low frequencies of Rh-negative individuals (as in the Lapps) but the high A_2-frequencies of south Sweden are combined with high Rh-negative frequencies (as in west European populations).

ii. Archaeological evidence suggests that early immigrations from west Europe occurred in south Sweden and in Jämtland (ARBMAN, 1947, and HALLSTRÖM, 1942). The highest frequencies of Rh-negative individuals (indicating a west European influence) are found in the same areas. Map 40, which combines AB0- and Rh-criteria for west European influence, also shows the same agreement. In the area with high Rh-negative frequencies in Jämtland, Stone Age rock carvings have been found. HALLSTRÖM (1942) considered these rock carvings to be related to similar finds in Norway and thus indicate an old western influence.

iii. Archaeological data also support the view that in about 3000 B.C. southwest Sweden received a considerable immigration — the megalithic people. The megalithic culture occupied mainly southwest Sweden (with a central area in Västergötland).

In accordance with this view, southwest Sweden is characterized by higher 0-frequencies and lower B-frequencies than southeast Sweden. The high 0-frequencies of south Sweden have approximately the same location as the megalithic culture and reach their maximum in Västergötland, the central area of the megalithic culture. As the high Rh-negative frequencies are spread over almost all south Sweden they were probably not carried by the megalithic people. The element with a high Rh-negative frequency may be pre-megalithic. The serological data suggest that the people with the hunting culture of southeast Sweden were of eastern origin, possibly from the Baltic States. Later, additional eastern influence may have been received from the immigration of the eastern group of the Boat-axe people. The question whether the different Stone Age cultures of South Sweden were carried by two biologically different peoples is an old problem in Swedish archaeology (cf. ALMGREN, 1914). FLODSTRÖM (1915 and 1918) has claimed that the racial and demographical differences between southwestern and southeastern Sweden go back to Stone Age conditions. The present blood group data suggest that there really may be old racial differences be-

tween the populations of the areas characterized by different Stone Age cultures.

iv. The high 0-frequencies of northern Sweden may evidently not be connected with the megalithic culture. Probably the high 0 reached northern Sweden past Norway at a considerably later point of time than south Sweden.

The high 0-frequencies of north Sweden are much stronger pronounced than in southwest Sweden which may depend on a higher degree of isolation in the north preserving the original frequencies, while the higher mobility of south Sweden may have levelled off the differences.

The question may be raised whether the present-day blood group variations found in the Swedish population really are due to as old immigrations as outlined above. There are, however, no evidence of greater immigrations at least to south Sweden during the last two millennia. LUNDMAN (1951 b) claims that no considerable foreign immigrations have occurred during the three last millennia. Stone Age archaeology, however, gives a lot of evidence of large migrations. Hence there are good reasons to believe that the major traits of variation, at least in south and central Sweden, depend on immigrations prior to the Scandinavian Bronze Age.

b) LATER MIGRATIONS (AFTER THE SCANDINAVIAN BRONZE AGE)

The following tentative agreements between blood groups and post-Bronze Age migrations may be distinguished.

i. Immediately before and around the birth of Christ the Lapps are thought to have spread down the country from their previous dwelling-places in northern Scandinavia and Finland (HALLSTRÖM, 1942). This southward migration may be responsible for the high A_2-frequencies (combined with low frequencies of Rh-negatives) found in the northern part of Sweden down to the Mälar district.

ii. About the time of the birth of Christ the Finnish tribes immigrated to Finland. It is possible that they reached northern Sweden sometimes in the middle of the first millennium A.D. Maybe most of the high B-frequencies of northern Sweden and especially those of the northern part of Västerbotten county are due to such early Finnish immigrations.

iii. During the Viking age there were lively communications between central Sweden and Russia. Some additional eastern influence may have been received in the Mälar provinces during this period, e.g., the high B-frequencies in eastern Uppland.

iv. After 1323 (the peace at Nöteborg), when Sweden got a definite political border against Russia, a systematic colonization of the northern parts of Sweden began. This may have caused an additional spread of high 0-frequencies and high frequencies of Rh-negatives to the coastal area of northern Sweden. Some earlier southwestern elements may have existed here but probably the Lappish and Finnish elements were prevalent. Anyhow the trade of north Sweden had been dominated by armed Finnish trading companies for hundreds of years.

v. During the sixteenth and seventeenth centuries large numbers of Finns immigrated to central Sweden, settling mainly in Dalecarlia, Värmland and Hälsingland (LÖNBORG, 1902). As previously mentioned this immigration is probably in part responsible for some of the highest B-frequencies found in southern Dalecarlia, though still older eastern immigrations may have contributed.

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SUMMARY

(1) Blood group data from 131,659 conscripts, 73,581 blood donors and 10,457 (8,488 for the Rh-system) unrelated individuals tested in paternity cases have been analyzed as to the regional variation of the gene frequencies. For the conscript material there are only AB0-data, for the blood donor material AB0- and Rh-data (pos. and neg.), and for the paternity material A_1A_2B0-, Rh- (C, D, and E), MN- and P-data.

(2) The total data for the conscript and blood donor materials showed significant inconsistency with expected frequencies concerning the AB0-system. The conscript material had a deficiency for AB and the blood donor material generally an excess of AB and 0. Concerning the AB0-system the consistency with expected frequencies was satisfactory for the paternity material.

(3) The heterogeneity between eleven main regions had a significance level of $P < 0.001$ for the A_1-, A_2-, B-, 0-, D-, E-, and P-genes and for the frequency of Rh-negatives. The heterogeneity for the M-gene had a significance level of $0.01 > P > 0.001$ and for the C-gene $0.05 > > P > 0.02$.

(4) High A-frequencies have been found in the northern and western parts of north Sweden and in the eastern parts of south Sweden. The lowest A-frequencies were found in Ångermanland. The highest A_2-frequencies were found in northern Sweden. Frequencies around and above 10 per cent were found also in south Sweden. Central Sweden on the whole, however, showed low A_2-frequencies (below 6 per cent and sometimes as low as 3—4 per cent). Similarly low A_2-frequencies have been demonstrated in Estonia.

The B-frequencies are relatively high in central Sweden, northeastern Sweden and in western and central Jämtland. Low B-frequencies were found in scattered localities in north Sweden and in the central part of south Sweden.

High 0-frequencies (above 70 per cent) were found in Ångermanland, southern Västerbotten and in Västergötland. The lowest 0-frequencies were found in Norrbotten.

(5) The frequencies of the C-, D-, and E-genes are high in north and central Sweden. The Rh-negative frequency is high in south Sweden, western Jämtland, the north Swedish coastal area and in eastern Gotland. Frequencies around 25 per cent have been observed in Sweden.

(6) The M-frequencies are high in north Sweden and in scattered localities in central Sweden (among others in Dalecarlia). The lowest frequencies were found in Bohuslän. Samples with a deficiency for MN-heterozygotes assemble in certain areas which seem to be relatively isolated.

(7) The highest P-frequencies were found in south Sweden. Low frequencies were found in Lapland and in central Sweden.

(8) AB0-, Rh-, MN-, P-, and Kell-data for 419 children from the Swedish nomad schools have been analyzed. A very high frequency of the C^w-gene has been demonstrated among the nomadic Swedish Lapps. Significant differencies between different subgroups of the Swedish nomads were found in the AB0-, Rh-, MN-, and P-systems.

(9) An attempt to divide the Swedish population into genetically different subpopulations has been made. This division shows good agreement with anthropometrical and archaeological data. No agreement with maps showing "the intensity" of the nordic race could be demonstrated.

(10) The blood group genetical results of this investigation suggest that the present-day Swedish population is composed of three main population elements — the west-European element, the east-European element and the Lappish element. The western element shows good agreement with the early European Population as defined by BOYD (1950). The Lappish element was probably differentiated from an early European group through long-time isolation in northern Scandinavia.

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